1985 NASA AUTHORIZATION

HEARING

BEFORE THE

SUBCOMMITTEE ON TRANSPORTATION,
AVIATION AND MATERIALS

OF THE

COMMITTEE ON
SCIENCE AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES

NINETY-EIGHTH CONGRESS

SECOND SESSION

FEBRUARY 9, 1984

[No. 69]

VOLUME I

Printed for the use of the
Committee on Science and Technology

U.S. GOVERNMENT PRINTING OFFICE
31-453 O WASHINGTON : 1984

H701-43

COMMITTEE ON SCIENCE AND TECHNOLOGY

DON FUQUA, Florida, *Chairman*

ROBERT A. ROE, New Jersey
GEORGE E. BROWN, JR., California
JAMES H. SCHEUER, New York
RICHARD L. OTTINGER, New York
TOM HARKIN, Iowa
MARILYN LLOYD, Tennessee
DOUG WALGREN, Pennsylvania
DAN GLICKMAN, Kansas
ALBERT GORE, JR., Tennessee
ROBERT A. YOUNG, Missouri
HAROLD L. VOLKMER, Missouri
BILL NELSON, Florida
STAN LUNDINE, New York
RALPH M. HALL, Texas
DAVE McCURDY, Oklahoma
MERVYN M. DYMALLY, California
PAUL SIMON, Illinois
NORMAN Y. MINETA, California
RICHARD J. DURBIN, Illinois
MICHAEL A. ANDREWS, Texas
BUDDY MacKAY, Florida
TIM VALENTINE, North Carolina
HARRY M. REID, Nevada
ROBERT G. TORRICELLI, New Jersey
FREDERICK C. BOUCHER, Virginia

LARRY WINN, JR., Kansas
MANUEL LUJAN, JR., New Mexico
ROBERT S. WALKER, Pennsylvania
WILLIAM CARNEY, New York
F. JAMES SENSENBRENNER, JR., Wisconsin
JUDD GREGG, New Hampshire
RAYMOND J. McGRATH, New York
JOE SKEEN, New Mexico
CLAUDINE SCHNEIDER, Rhode Island
BILL LOWERY, California
ROD CHANDLER, Washington
HERBERT H. BATEMAN, Virginia
SHERWOOD L. BOEHLERT, New York
ALFRED A. (AL) McCANDLESS, California
TOM LEWIS, Florida

HAROLD P. HANSON, *Executive Director*
ROBERT C. KETCHAM, *General Counsel*
REGINA A. DAVIS, *Chief Clerk*
DAVID S. JEFFERY, *Minority Staff Director*

SUBCOMMITTEE ON TRANSPORTATION, AVIATION AND MATERIALS

DAN GLICKMAN, Kansas, *Chairman*

ALBERT GORE, JR., Tennessee
MERVYN M. DYMALLY, California
RICHARD L. OTTINGER, New York
TOM HARKIN, Iowa
MICHAEL A. ANDREWS, Texas

WILLIAM CARNEY, New York
SHERWOOD L. BOEHLERT, New York
ALFRED A. (AL) McCANDLESS, California

CONTENTS

WITNESSES

February 9, 1984:	Page
Dr. John J. Martin, Associate Administrator for Aeronautics and Space Technology, National Aeronautics and Space Administration; accompanied by Dr. Raymond S. Colladay, Deputy Associate Administrator for Aeronautics and Space Technology	3

APPENDIX

Letter from Air Transport Association of America	77
Letter from Delta Air Lines, Inc	78

1985 NASA AUTHORIZATION

THURSDAY, FEBRUARY 9, 1984

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND TECHNOLOGY,
SUBCOMMITTEE ON TRANSPORTATION,
AVIATION AND MATERIALS,
Washington, D.C.

The subcommittee met, pursuant to notice, at 10:06 a.m., in room 2337, Rayburn House Office Building, Hon. Dan Glickman (chairman of the subcommittee) presiding.

Present: Representatives Glickman, Dymally, Carney, and McCandless.

Mr. GLICKMAN. Good morning. The subcommittee will be in order.

This is the first day of our hearings on at least this subcommittee's part of the NASA reauthorization bill. The fact that we are meeting here, while we are grateful to the Armed Services Committee for giving us this room, does not mean that we intend to yield the control of NASA to the Defense Department. I thought I would make that clear, at least for the record, early on.

Today, we will continue our consideration of NASA's aeronautics program and, in particular, the 1985 budget request.

Last December, the subcommittee held a hearing which we called the future of aeronautics. Among the testimony at that hearing was a report from the Aeronautical Policy Review Committee, a group constituted by the White House Science Adviser, Jay Keyworth, to review long-range Government research and technology plans for consistency with the administration's aeronautical R&T policy.

In its findings, the group, which included a broad spectrum of representatives from industry, academia, and Government, stated that the current U.S. research effort is generally consistent with the technical aspects of the policy; but it is not consistent with the bold leadership spirit expressed in the policy.

In looking at NASA's request for fiscal year 1985, I find that I must agree with this assessment. While it is reassuring to see that the administration has finally stopped trying to kill aeronautics, I see little in the way of visionary initiatives, the kind that will be needed in the 21st century.

The effort in hypersonic and supersonic research, for example, is miniscule. Yet this frontier is one with tremendous potential for both civil and military applications. Rather, I see a perpetuation of past thinking which embodied a policy of holding the line and which has left us with optimized versions of 1950's technology.

As I have said on several occasions, we need a new approach, one in which NASA takes an aggressive lead in pursuing new technologies and applications. We need to focus on new airframe materials and propulsion systems, and we need to explore in manned flight the region beyond the X–15 envelope.

In looking at the budget, I was also disappointed not to see funds for a flight test of the propfan. I believe the time has come for such a test and that it is a proper task for NASA to undertake.

To assist us in reviewing the NASA aeronautics program, we have invited NASA's newly appointed Associate Administrator for Aeronautics and Space Technology, Dr. Jack Martin. I was encouraged when I recently met Jack in my office. I believe he shares many of my concerns about the need to advance technology vigorously.

So I look forward to working with him and his office in the future, as well as his testimony today.

Now I would like to call on Bill Carney, ranking member.

Mr. GLICKMAN. Carney. Thank you, Mr. Chairman.

I join the chairman in welcoming you, Dr. Martin, to testify before the subcommittee today. I must say NASA wastes no time in putting their managers on the firing line. You have barely learned your way around your office, and already you are up here defending NASA's budget. I think this is your second trip up, if I am not mistaken.

As a strong supporter of NASA's aeronautics programs, I was pleased to see the 13-percent increase in the budget request, although, in the face of $180 billion-plus deficit, I confess that I have some mixed feelings about it.

I am pleased to see that this budget is generally consistent with the administration's philosophy on basic research. It reflects a strong commitment to the long-term fundamental research that is so essential if we are to make the big breakthroughs that the chairman has been asking for.

The research that NASA is doing in advanced propulsion systems, and materials, and structures will lay the foundation for the advanced flight research vehicles that we all want to see.

The continued emphasis on computational methods and capabilities is also well placed and should reap large dividends in the future.

This subcommittee is, and continues to be, dedicated to a strong aeronautics research program. However, when huge deficits are being forecast far into the future, we have to find innovative ways to fund the research.

As resources become even scarcer, there are going to be increasing needs to manage these resources efficiently, to insure that there are no duplications of effort. This might mean more joint programs if the goals of NASA overlap those of other agencies. And, although a certain amount of overlap among the NASA centers is inevitable, NASA must take care to see that these programs are generally complementary and not merely duplications.

Industry is also going to have to share a larger responsibility for those programs which directly benefit their particular interests. Therefore, I was particularly pleased to see the way the helicopter industry is approaching the noise problem. The joint program that

NASA is conducting with the American Helicopter Society to study noise reduction is a model which I hope to see emulated by other elements of the aviation industry. It is indeed encouraging to see an industry willing to pool their resources to find solutions to the problems which stand in the way of their success.

I look forward to hearing from you and getting an overview of the NASA programs for the coming year. I am particularly interested in your views on how we can effectively utilize the combined resources of government and the private sector to solve some of the problems facing us in aeronautics today.

Thank you, Mr. Chairman.

Mr. GLICKMAN. Thank you, Mr. Carney.

Mr. McCandless, do you have any comments you would like to make?

Mr. MCCANDLESS. No, thank you, Mr. Chairman. I have a number of questions at the appropriate time.

Mr. GLICKMAN. Thank you.

Dr. Martin, it is a pleasure to have you here today. Why don't you go ahead?

STATEMENT OF DR. JOHN J. MARTIN, ASSOCIATE ADMINISTRATOR FOR AERONAUTICS AND SPACE TECHNOLOGY, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, ACCOMPANIED BY DR. RAYMOND S. COLLADAY, DEPUTY ASSOCIATE ADMINISTRATOR FOR AERONAUTICS AND SPACE TECHNOLOGY

Dr. MARTIN. Thank you, Mr. Chairman and members of the subcommittee. I am pleased to be here today to present NASA's fiscal year 1985 aeronautical R&T budget to you.

I have with me my Deputy, Dr. Raymond Colladay, and I brought also my Division Directors in the event that there are some very detailed questions which I might not be able to handle.

With your permission, I would offer the formal statement for the record and make some informal comments.

Mr. GLICKMAN. Your entire statement will appear in the record at the conclusion of your oral presentation.

Dr. MARTIN. As you have noted and as Mr. Carney has noted, this is my first meeting with you as Associate Administrator. However, I have had a substantial interest in NASA's research and technology activities for many years when I was in the Department of Defense, particularly in the Air Force. At that time I was Assistant Secretary for Research and Development, and there was a good deal of interaction between my office at that time and the appropriate NASA offices, in particular OAST, and we depended very much on NASA and had a very high regard for their programs. I intend, in the efforts that I now manage, that that high quality that I think I perceived at that time will be maintained and intensified in the future.

As a consequence of my being familiar with the Government budget process, I know the guidance and support of this subcommittee is very important to us, and I intend that we will do our work in such a way that we will continue to merit that support, and we hope to continue to get that guidance so that we can meet

the goals that we have set for ourselves and that you have helped us set.

The United States has been preeminent in aeronautics for a number of reasons. Not least—in fact probably the major factor—has been the superior technology which we have had. Another factor has been the imaginative way in which industry and the DOD have made applications of technology, filling market needs with state-of-the-art products. I see it that it is our responsibility to continue to provide technologies which will keep us in that position. Furthermore, our own large domestic markets have given us a production base that has provided prices of our products that have been acceptable to the market and have been a major contributor to a manufacturing scale of production and to product in-service support.

Foreign sales also have been important to us, and we need, I think, very much to continue our ability to penetrate foreign markets. We now face very aggressive competition from foreign producers who are in some cases supported by their governments. As a result, the competition is tougher than ever and the need for good technology, applicable technology, is greater than ever as well.

As I have said, in assuming these responsibilities, I intend that we will perform at least as well as we have in the past and that we will merit your support in the activities that we are carrying on. I believe we have a well-balanced program for 1985. It includes a solid base of fundamental research activities in critical aeronautical disciplines that will serve us in the long term. It also includes, the program that is being recommended to you, systems research directed at interactions of the several disciplines that we work in, together with components and subsystems that are related to general classes of advanced civil and military aircraft.

Here is the 1985 budget (fig. 2) broken down by technical area, which is familiar to you from the budget narrative material. There is, as noted, an increase in the budget over fiscal year 1984, including about a 6-percent growth in the R&T base, and, as Mr. Carney has noted, a 13-percent overall growth.

Some of the buildup in the budget is attributable to the advanced composites structures program to which we would add $14 million, and the numerical aerodynamics simulation program, to which we would add $9.5 million. We are also requesting an acceleration of the rotor systems research aircraft X-wing flight program, with an added $10 million, so that we can initiate testing of that craft by the end of 1985.

On this chart (Fig. 1) is the 1985 budget request which is being made to you, compared with 1983 and 1984. The budget request is for $342.4 million, the 13-percent increase that has been mentioned.

Here is the total NASA aeronautics program (fig. 3), a total of $687.1 million, 50 percent of which is from R&D, 46 percent from research and program management funds, and 4 percent from construction of facilities.

The R&PM supports 3,762 direct work-years, and the construction of facilities is essentially for the NAS, the Numerical Aeronautic Simulation building, and for modifications to the 8-foot high-temperature structures tunnel.

The pie on the right side shows where the R&D budget goes, 97 percent of it to the three research centers; the balance at Goddard, Johnson, Marshall, JPL, and some at Headquarters. The split among the three research centers is about even, 39 percent to Ames, 34 percent to Langley, and 24 percent to Lewis.

This is the way we spend the R&D funds (figure 4), all of which is out of house. The in-house part that is listed there means that those funds are spent 60 percent or so for the support of in-house research but spent outside of NASA. The rest is in research grants and research contracts with universities and with industry.

The major elements (figure A), the major programmatic thrusts that I am going to now get into with your permission are listed in these charts. You see four technology drivers, as we would call them, key areas that have disproportionate payoff if we are successful in them, in structures, aerodynamics, propulsion, and flight controls. Then, toward the end of what I have to say, I am going to get into a couple of specific research vehicles that are listed here, rotorcraft and high-performance aircraft.

First, (figure 5) I would like to get into the subject of aircraft structures. The driving factors are competitive need for increased performance and reduced cost of airframe. The efforts that are under way, as you see, are primarily toward weight reduction through the advanced composites program, primarily; improved manufacturability using better, new manufacturing techniques and some automation; and to high-temperature structural materials. I will say a little more about some of these.

The aircraft-weight-reduction efforts (figure 6) are important because they reduce operating costs. If you are pushing less weight through the air, it costs less in fuel, and it permits an increase in payloads, both of which are, of course, important.

The use of composites to this time has been primarily in nonload bearing or secondary structures such as doors, and panels, and that type of application. If we could carry that to the limit, which would be up to a 25-percent savings[1] in weight of the structure, we could have a 15-percent decrease in overall aircraft weight. That would be important in itself. But, the advanced program seeks to push further the efforts that we have already done in nonload-bearing structures and to try to get composite materials into load-bearing structures such as wings, and fuselages, and the like, which would be an additional savings, if successful, over what we have accomplished to the present time.

The efforts are going on that we have contracted with at Lockheed, Boeing, and Douglas, and what we are trying to do is develop the critical technology information that we require so that we can design, and fabricate, and know how to test adequately the use of composites in these applications that we have spoken of.

There is effort under way also at Langley Research Center to address design issues and to identify technologies which will permit us to carry on even beyond the efforts that we currently have in mind.

Another driver (fig. 7), so to speak, with respect to materials is in improved manufacturing techniques and processes which could

[1] Footnote to changes in lines 281 and 282 to clarify "savings."

bring lower cost and more efficient aircraft structures. There have been advances in powder metallurgy, one of which is the increasing of stiffness and strength of aluminum alloys through extremely rapid cooling rates that permit the development of alloys of chemical compositions that are not, by conventional methods, available to us. So we are getting into that. It offers high promise and it has the added advantage that if we are successful, as we believe we will be, there will be no major capital investments required by industry to make use of the materials that are developed.

An unrelated but another technique that offers considerable promise is superplastic forming which allows the development of products which are extremely useful to us in that the depth of draw is greater than normally would be expected or anticipated. Because of this, it saves a good deal of labor, and time, and permits complex shapes to be produced at considerably reduced cost.

High-temperature structural concepts (fig. 8) are being worked on, also, to provide long-lived structures at temperatures from 700 to 1,800° Fahrenheit, a speed range which corresponds to something like mach 3 to mach 4½, beginning to get toward very high supersonic or low hypersonic cruise mach numbers. The concepts that we are working on that are being investigated at Langley are for skin panels, hot substructures, and thin superalloy foil panels. The skin panels are trying to accommodate high-thermal gradients. The hot substructures are for the purpose of taking on high loads within the craft with low-thermal stresses. The superalloy foil panels are for radiative heat transfer control in hypersonic vehicles.

Some of these efforts will be evaluated in hypersonic facilities where we can combine thermodynamic and aerodynamic loads on the panels that we are working on.

I am going to move now to aerodynamics (fig. 9), and this chart shows the key drivers, the key areas that are of importance to us. They are drag reduction, improved simulation techniques, whether analog or digital, and improved maneuverability.

Drag reduction (fig. 10), as I alluded to a few minutes ago, translates directly to fuel savings, and to range increase, and other performance benefits. One of the efforts that we have been involved in is laminar-flow-control concepts, with a Lockheed Jetstar aircraft, shown on the chart. We have demonstrated the feasibility of laminar-flow control, and now we want to demonstrate further a couple of approaches, one with porous walls, one with slotted walls, including leading-edge contamination effects. The bugs that get destroyed on the leading edge tend to destroy laminar flow, and we are trying to work around that as well.

Recent discoveries with respect to turbulent flow have led to friction-reducing devices that offer up to 15-percent reduction in fuselage drag. Two of these, shown schematically, are riblets and large eddy breakup devices, and we would flight-test these during 1985.

One of the ways of simulating (fig. 11) is through wind tunnels, and I bring up here the National Transonic Facility, which offers us opportunities for reducing development cost and time for aircraft through the capabilities that it has.

Wind-tunnel testing will begin shortly. The tunnel was dedicated in December 1983, as I think you know. The tunnel and, as you

might call it, the air which flows in it are cryogenically cooled to simulate full-scale Reynolds numbers, which are extremely important in trying to assess drag of aircraft fuselage because of the very great sensitivity to Reynolds number effects. Our initial efforts are going to be with what we call pathfinder models, which will represent transport aircraft and high-performance aircraft, as a way of probing out the general capabilities of the tunnel and how it might be used more specifically, more precisely in the future.

I would like to say a few words, also, about the numerical aerodynamic simulation program (fig. 12), referred to as NAS. Fluid physics computational capability will be provided through this NAS program, which will offer us a capability that will be unparalleled in the world. It will, incidentally, challenge the supercomputer industry in this country and in the world, for that matter, because we intend it to be an evolving capability which will at any given time be using state-of-the-art machines for the calculation of fluid dynamics situations.

The NAS system consists of high-speed processors. The initial operating configuration will have a Cray 2 in it, and it consists also of a graphics output, mass storage, long-haul communications, and user support processing software and hardware. We anticipate that the Cray 2 will be installed in 1985 and that the initial capability will be available to the Nation in 1986.

With respect to increased maneuverability (fig. 13), it certainly offers enhanced survivability to military aircraft and permits also more versatile and precise weapons delivery. We are, therefore, quite interested in the subject. Our research is directed toward efficient cruise and effective maneuver over the entire flight envelope of aircraft of the future. The specific technologies that we are looking at the present time are improved turn radius, better agility, and high-pitch-angle-performance capabilities, all of which the modern aircraft have to some degree, but they could be enhanced.

Some of the areas that we are pursuing are vortex-lift-augmentation systems. There is a diagram showing vortex flaps in one of the chart, upper left. Also, we are looking into thrust vectoring through the use of aft-mounted vanes in the exhaust as a way of improving maneuverability; and also we are looking at variable camber wings, which have that same effect. All of this is planned for fiscal year 1985.

The next programmatic thrust that I would get into is propulsion (fig. 14). The major thrusts that we have here are for improved fuel efficiency, increased thrust-to-weight ratio, and increased engine durability.

A program called Host, short for hot section technology, is addressing the question of engine durability. High-temperature materials is the direction that appears to offer improved engine cycle efficiency as well as increased thrust-to-weight ratios in engines. Efforts such as the advanced turboprop program and the advanced rotary and diesel engine research work which we are carrying on and propose to continue improve fuel efficiency of transport and general aviation aircraft.

I mentioned Host (fig. 15). It will bring together advances in materials, cooling technologies, computational tools, and design and fabrication concepts, all of these to improve durability and per-

formance. Host is a cooperative program among industry, universities, and NASA, and we are working on combustion processes, thermal-structural components, and hot corrosion of materials, all of which you see here in the images that are on the slide. The major element of the program is improved high-temperature gas turbine instrumentation so we can get critical data for model validation.

The advanced turboprop program (fig. 16) offers the potential for very high efficiencies at mach numbers up to 0.85, something in the range of 560, 570 miles an hour. We have both contracted and in-house efforts under way which are laying a basis for developing the critical—that is to say enabling—technologies. During 1985, we would work on propfan-engine-inlet aerodynamics with the inlet located behind the propeller; some wind-tunnel evaluation of single and counterrotating propfan models; an advanced counterrotation engine research area of development; other installations—aerodynamics with nacelle wing drag being taken into consideration as well as noise vibration and the like.

Finally, we would do large-scale ground tests with a realistic propfan using a gearbox and engine-on-wing configurations.

At the present time, we are pursuing all of the elements of the program so that we can keep future options open for necessary-systems technology development and flight-test when that becomes appropriate to do.

For many years, general aviation (fig. 17) seems not to have benefited from the propulsion innovations that military and civil commercial aircraft have. We are presently, through contracted efforts and in-house work and university grants, focusing on reducing fuel consumption and weight of rotary engines and high-temperature diesel engines that are appropriate to general aviation aircraft.

NASA's R&T base program will carry out work on breadboard engines that work on advanced combustion and fuel technologies, advanced materials such as ceramics, and new component-technology-validation experiments. We will carry out a readiness demonstration of either the rotary engine or the diesel engine sometime in 1985.

Now I would like to get into flight controls (fig. 18). Flight controls are the interface between the pilot and the airframe; in fact, maps the dynamic behavior of one into the other and controls the aircraft in the process. The emerging technology of digital flight controls offers dramatic increase in performance through integration and through automation, which is probably in the first year or two of its existence, that integration and automation.

NASA's goals in this technology area are to develop advanced flight control concepts and look for opportunities which focus mainly on reliability, on aircraft stability requirements, and, as I said, on integration and on automation.

Our research in these digital controls (fig. 19) focuses on reliability and safety of new concepts. The avionics integration laboratory, called AIRLAB, became operational in 1983. In 1985, we are going to concentrate on modeling and analysis of fault-tolerant concepts so that we have a basis for predicting system reliability. We are also going to work on system recovery capabilities after outages and transients which were brought on by natural or other causes.

We will simulate this through introducing artificial faults into components. Beyond that, we look to try to develop methods for predicting probability of failure of individual components and of systems architectures.

The improvements (fig. 20) in aerodynamics and structures and propulsion require the advances in controls technology that I have talked about so as to expand the capabilities of the aircraft, generally high-performance aircraft, to the full envelope of their capabilities.

The application of these controls permits a reduction of the natural stability of the aircraft, which in turn permits a reduction in the size of controlled surfaces, reduces their drag because they are smaller, and permits a more flyable, a more maneuverable aircraft. Before we can go very far, however, we have to be able to carry out a validation of the control theories through simulations and through flight tests, and we will continue this effort during 1985.

The ever-increasing complexity (fig. 21) of control functions requires the kind of integration that I have talked about; for instance, the close coupling of airframe dynamics, engine inlet aerodynamics, and the control of engine parameters.

In 1985, at both Lewis and Langley, in cooperation, selected control system architectures and various thrust vectoring concepts will be evaluated by analysis and also by piloted simulations.

In addition, flight tests will be initiated at Dryden with an F-15 that has a highly integrated digital electric control system, and it will be assessing the integration of flight path management and throttle functions, which is to say flight control and propulsion functions (fig. 22) that we would be developing.

I am going to move now to the first of the two research aircraft that I mentioned: rotorcraft. We have been working with industry to establish the technology needed for the next generation of rotorcraft. The key drivers are ride quality, productivity, and speed. With respect to ride quality, it essentially gets down to reducing vibration, and that impacts on the passengers and crew. Our eventual goal, our ultimate goal, is a jet-smooth ride in a rotorcraft. That might be some time off, but that is our goal.

A sophisticated understanding (fig. 23) of the unsteady aerodynamics or large-scale turbulence that accompanies the aerodynamics of the rotorcraft and a sophisticated understanding of structural dynamics of rotorcraft could lead to a 50-percent reduction in airloads and vibration. In 1985, measurement and analytical prediction of complex rotor aerodynamics will be carried out with that end in mind. Currently, the research on unsteady aerodynamics which is unique to rotors will be expanded by trying to apply theories that have been proven with fixed wings to rotorcraft. That will be a challenge, but it is one we are undertaking. We also would undertake comprehensive wind tunnel tests to validate the aerodynamic and structural theories.

Finally, we have as a bottom line wanting to get to full-scale rotor systems in the 40-by-80-by-120-foot wind tunnel in 1986.

We have gotten into a consortium (fig. 24), so to speak, with FAA and the American Helicopter Society in addressing noise reduction. In addition to that, Bell, Boeing, Hughes, and Sikorsky have joined together with the Government, with NASA and FAA, to share re-

sults of their theory fundamentals and of their noise reduction research.

In 1985, parametric models will be tested and flight data on rotor airloads will be acquired so that we can try to eventually get to our goal of having an acoustic theory which will permit an understanding of noise generation. Our expectation is that by 1987 we will be able to predict noise to within three decibels, a factor of two, in new helicopter designs.

The benefits (fig. 25) that can be achieved by increased speed in future missions are causing an examination of new concepts such as the X-wing rotor aircraft. We are in a joint program with DARPA using the rotor systems research aircraft to validate aerodynamic and dynamic predictions in start/stop conversions of the rotor at about 200 knots.

This program is using NASA facilities at Ames Research Center in conjunction with Sikorsky's expertise on rotor design and fabrication for modifications of the aircraft. We will carry out hover and low-speed flight characteristics in the low-speed wind tunnel and move on then to high-speed fixed rotor characteristics in the transonic wind tunnel test.

I mentioned the 40 by 80 by 120 (chart B), and I thought I would insert here a status report of that tunnel's repair activities. The total project is presently scoped and will remain scoped at $26.5 million, with a completion date of December 1985. Key elements in the repair schedule are the replacement of motor housings, fan blades, and vanes, which is to be accomplished by June 1985, and the other key element is integrated test and system verification when all of that work has been accomplished, that by December 1985.

The status presently is that everything is on schedule. The fan blade delivery is on schedule. The vane set bids are out, and all of the work, as I said, is on schedule. We intend to keep it that way.

The other aircraft type (fig. 26) that I mentioned is high-performance aircraft. It is our objective to discover and explore advanced concepts which are applicable to high-performance aircraft. In connection with that, we will attempt to generate and validate design methodologies that are applicable to high-speed aircraft and missiles of the future. This chart shows the key elements of the program to be supersonic cruise, short takeoff, and vertical landing, STOVL, and hypersonic air-breathing aircraft and missiles.

The STOVL research (fig. 27) is directed at an aircraft with a supersonic capability, short takeoff, landing within a 400-foot takeoff distance, and having a vertical landing capability.

A McDonnell Aircraft Co., two-engine concept has been studied and analytically treated and also tested in wind tunnel models, and our plan for 1985 calls for wind tunnel testing of a single engine STOVL concept attributable to General Dynamics. The research efforts are being conducted also on flight control technology so that we can control such a STOVL aircraft if it is an aerodynamic possibility.

In fiscal year 1985, the Ames vertical motion simulator will be used for a piloted evaluation of integrated aircraft and propulsion controls, a sine qua non in such an aircraft, by the way.

NASA and DOD are considering a joint program with the United Kingdom with such an aircraft as well. It is only in the very preliminary stages, the talking stages, at this time.

Regarding hypersonic aircraft and missile technology (fig. 28), our program is directed toward a technology base needed for the Mach 3 to Mach 8 range. Initially, hydrocarbon fueled air-breathing aircraft and missile concepts will be evaluated in wind tunnel tests at Langley, and subsequently we will push toward a dual-mode propulsion for aircraft combining turbojet and ramjet.

In the missile propulsion, we would emphasize the adaptability of hydrocarbon fueled supersonic combustion ramjet engines—scramjets, so-called—to a near-term goal of hydrogen technology in such a scramjet. To do this, we will use the 8-foot high temperature structures tunnel at Langley after it has been upgraded so that it can accommodate the relatively large scramjets, these in the range of Mach 4.5 to 7.0.

Here are some of the experimental aircraft and research aircraft (fig. 29) that we have recently and currently been using. They are essential to us when there are questions, unresolvable questions, of scale effects, interaction among components, and overall feasibility of aircraft systems.

We have had a number of cooperative programs with such aircraft with DOD and industry so as to make a new technology evaluation, and we hope to continue that kind of effort in the future. The kinds of aircraft that we have used, had available to us, are high-performance fighters, rotorcraft, and general aviation aircraft. The montage shows you some that we have had recently.

Such aircraft (fig. 30) are essential because flight research is the ultimate way of carrying out or proving of concepts analytically and through models and simulation. We need to resolve questions of scale, flight environment, dynamic behavior, flying qualities, and the intepretation of technologies.

In fact, one such is the oblique wing, which is shown in this chart, which has potential military and possible civil importance. Flying qualities, aeroelastic behavior, and transition require flight research at transonic speeds. We have carried out the low-speed research in the AD–1 which is shown, and we believe we can modify existing aircraft to a flight research vehicle for higher speeds.

Vortex flap, augmentor/ejector, and 2–D nozzles could be important for future high-performance aircraft, either STOL or STOVL capability, and new supersonic research aircraft are required to investigate overall feasibility, flight control, and propulsion control integration. Scramjet propulsion involves integrated advances in propulsion, structures, and aerodynamics which are currently under evaluation at small scale, but eventually a new research vehicle will be needed to carry out further tests.

Mr. Chairman, I have tried to highlight to you the major thrusts of the NASA aeronautics program being proposed to you for consideration in our fiscal year 1985 request.

I have given you some detail this morning. There is considerably more detail in the narrative material. I believe it is a good program, a healthy step toward assuring U.S. preeminence in aeronautics, and I am confident that with the continued support of yourself

and this subcommittee, we will attain our ambitious goals in the future.

Thank you for this opportunity.

Mr. GLICKMAN. Thank you, Dr. Martin, for an excellent statement.

I think we are going to get along just fine. I think you presented NASA's program budget very clearly. While we may have some disagreements, which we will talk about right now, it is heartening to see that there have been increases in the program budget by the administration, and while I would like to see more, I kind of agree with Mr. Carney: I don't think, given the nature of the deficits, that in terms of aggregate numbers, we can go much higher than what the President has recommended. But we may have some differences on the constituency of those numbers, and that is what I would like to ask you about now.

In the first place, you gave us a lot of past history and current history about NASA. I want to know exactly, if you had to identify now what you would call experimental aircraft that NASA is involved with, I wonder if you would list those for me. What experimental aircraft are currently being operated? Any?

Dr. MARTIN. It depends upon the definition of operating, Mr. Chairman. We are heavily involved in the X-29 aircraft, which is about to have its first flight pretty soon.

Mr. GLICKMAN. Is that the Grumman?

Dr. MARTIN. The forward swept wing. Yes; that is right, the forward swept wing aircraft.

Mr. GLICKMAN. All right.

Mr. MARTIN. I mentioned the AD-1. I mentioned the X-wing work with Sikorsky, I believe, those three, and perhaps Dr. Colladay would mention some others.

Mr. GLICKMAN. We have some that you worked on in the past, like the tilt rotor, which I assume that your work is substantially completed on that one.

Dr. COLLADAY. It is, Mr. Chairman, but we still have selected technologies, advanced blade, multiblade configurations on that vehicle that we will continue to test, and handling qualities.

But essentially, the tilt rotor activity has been completed. What we will continue on is where that vehicle is of value and support to the JVX program. It is a resource in that sense.

Mr. GLICKMAN. Now, you have proposed no new experimental aircraft. Is that correct?

Dr. MARTIN. Yes; that is correct.

Mr. GLICKMAN. I have made comments before that I think that we ought to be moving into high speed, you know, the hypersonic aircraft, the X-15 type envelope, and pursuing that.

While you have not recommended that in this budget proposal, do you see that as a possibility for NASA to explore?

Dr. MARTIN. It is a possibility to explore it, Mr. Chairman. The view I think we have at the present time is that the technology has not been developed to the point that it requires a big push; that is to say, it is still in the phase, I believe, that the technology is going to do the pushing rather than some seen application doing the pulling. It is kind of a technology push/market pull sort of thing that I am talking about, and I don't see that.

Mr. GLICKMAN. Well, wait. We didn't develop the X-15 because of any push or pull. We developed it because we wanted to move ahead with that technology and whatever spinoffs there were, irrespective of what the market forces were. That is one of the great things about NASA.

What I am trying to get at right now is this: Are we going to wait until our friends in other parts of the world develop this kind of aircraft technology before we move ahead, or are they even contemplating that?

Dr. MARTIN. Who is "they," sir?

Mr. GLICKMAN. Well, it could be Western Europe.

Dr. MARTIN. I think not, from what I have heard and what I have learned. Let me back up a moment and say the introduction of the word "market" was an analogy which was unfortunate. I didn't mean to suggest that there was a commercial application, but just that the level of the technology in those high supersonic and hypersonic velocities is not yet to the point where one would feel a strong compulsion to put a lot of money in to push it. That could very well come, and we would be sensitive to it when it did, but I just don't see that it is here.

Mr. GLICKMAN. Do you mean that we are just not ready technologically to move into that kind of an airplane?

Dr. MARTIN. I think it would be inefficient to spend very large sums at the present time, I guess is what I am trying to say.

Mr. DYMALLY. Mr. Chairman, in that vein, could you give us an update on the project?

Mr. GLICKMAN. We will. The propfan, yes. We will get into propfan. I am just exploring hypersonic right now.

Well, I am wondering whether the hypersonic and supersonic R&T is not underfunded with respect to other areas. You know, I don't see very much of your allocation in that area.

Dr. MARTIN. We made a judgment of what was a good balance, Mr. Chairman, and that was the way it came out.

Mr. GLICKMAN. All right. Now let me move into propfan. Mr. Dymally has raised that question.

I judge there to be pretty strong support on this committee to move ahead with propfan. Why did you choose not to move ahead with it, at least in terms of the systems technology work as previously contemplated in earlier budget requests?

Dr. MARTIN. It was primarily a matter of the recommendation that was made, as I think you know, by NASA to OMB. It did not pass, so to speak.

Mr. GLICKMAN. So OMB basically put the kibbosh on the accelerated development of propfan?

Dr. MARTIN. I hate to subscribe to the exact words, Mr. Chairman, but it didn't make, so to speak, in the final budget effort.

Mr. GLICKMAN. Now, I wonder, if this committee decided to move ahead with propfan, what various budgetary options might there be, and how would you feel about reprograming from the R&T base, as we did last year?

Dr. MARTIN. Well, last year it was a sum that is tolerable to do. It is more than twice as much this year than last year. So it would begin to hurt to do that.

The total cost of that program, I think, is something like, what?

Dr. COLLADAY. $126 million total for the flight phase.

Dr. MARTIN. That is big dollars compared to the total size of the program in any one year, so it would change the landscape very considerably over a few years to do that. So I guess I would be reluctant to say that I would recommend that.

Mr. GLICKMAN. Well, how much would we be talking about in 1985? An additional $25 million?

Dr. MARTIN. Yes; $25.7 million was the number.

Mr. GLICKMAN. So you are saying that might be tolerable in 1985, but in future years, it would take too big a chunk out of the budget?

Dr. MARTIN. I think it would—yes. I said it would change the landscape. That is figurative, but——

Mr. GLICKMAN. But your original recommendation to OMB was to go ahead with that plan, wasn't it?

Dr. MARTIN. That is correct. Our recommendation to the Administrator and his to OMB was along those lines. That is right.

Mr. GLICKMAN. Along the lines of $25 million additional in fiscal year 1985?

Dr. MARTIN. That is right.

Mr. GLICKMAN. And if that recommendation had gone through, would the money have been reallocated or reprogrammed from the R&T base?

Dr. MARTIN. I think it was an augmentation, Mr. Chairman, so it would have been new money. Should you add something?

Mr. COLLADAY. That is correct; it was an augmentation. It was requested as an augmentation to the budget.

Mr. GLICKMAN. I am going to let the other committee members speak for themselves, but I think you are going to find general support for continuation in an augmented fashion, and given the fact that we are probably pretty much hemmed in by some aggregate number figures, we are just going to need to get together and talk about how that is going to be done, because I am going to suspect that very few of us are going to want to let that program languish. We either go ahead with it as originally planned or we stop it, and I am going to guess that the former alternative is what most members are going to want to do.

But let me ask you this question. In a world of volatility, we now see fuel prices, aviation fuel prices, having dropped—at least the commercial carriers tell me that they can buy jet fuel for, in some cases, 50 percent less than what they could last year.

Does the fact that you gave the Administrator the recommendation to proceed with propfan still indicate that you believe that it is an important systems technology program in light of, let us say, changing fuel prices and other things?

Dr. MARTIN. I do, and it is based on conversations with people in industry who have come in and supported very strongly—both the users and the manufacturers of engines and airframes continue to think that it is a very good possibility that it will maintain its economic attractiveness in the future.

Mr. GLICKMAN. What about some form of cost payback by industry when a successful product is introduced?

Dr. MARTIN. We have done that, I am told, Mr. Chairman. I don't have any experience with it. I think Dr. Colladay has a few words he might say on that subject, however.

Dr. COLLADAY. Well, in those programs, as you know, that are close in and deal with improvements in components in existing aircraft in production, as some of the elements of the aircraft energy efficiency program, we did have cost recovery or recoupment clauses in those.

We feel that the advanced turboprop, however, is such high risk and of a research nature that needs key technical questions answered, that it is appropriate for NASA to pursue that, because we don't see specifically what products are on the horizon that are close to development. But some key questions need to be answered.

We are always looking for ways we can improve cooperative efforts with the industry and share the burden of cost, and I think the industry has demonstrated their feeling of importance in this program by putting their own money into it over the years as well.

Mr. GLICKMAN. Let me, before I move on to Mr. Carney, just ask you two more questions.

I am pleased that you are moving ahead with NAS, the simulator, and the effect it will have on supercomputers in this country is, I think, demonstrated as you indicate, but do you see any duplication between it and any of the strategic computinq initiative of DARPA, anything the Defense Department is doing?

I have this nagging suspicion that, somewhere in the bowels of the Pentagon, they are developing an identical system to the numerical aerodynamic simulator, and we don't know anything about it.

Dr. MARTIN. The answer is, I have not looked into the DARPA computer program, but I think that Dr. Colladay is informed enough to answer that question for you.

Dr. COLLADAY. Well, we had that same concern, and I can assure you that somewhere in the bowels of the DOD they are not developing and pursuing the large scientific computing capability that we are with NAS.

We are very well informed and in fact are participants on the Federal Coordinating Committee [Council on Science, Engineering and Technology (FCCSET)] that is looking at the Government role in supporting our computer industry and the application of high-speed computers. Both through the steering group of that committee as well as three working groups, NASA is participating. One of those working groups is specifically directed and focusing on the strategic computing initiative, and that initiative is not directed at large-scale scientific number-crunching machines, as we are doing with the NAS, but is instead heavily based in artificial intelligence and expert systems and information processing.

Mr. GLICKMAN. Well, I think that this subcommittee, while I fully expect us to go ahead with this program, ought to have good, solid, independent verification that there is no substantial duplication occurring, because there just isn't enough money to do two systems that we might ultimately find do 90 percent of what the other system does.

So I fully expect us to go ahead with that, but I want this independently verified to insure that there is no substantial duplication

with what DARPA is doing. I assume that we will just again be cooperating in trying to determine that information.

Dr. MARTIN. Mr. Chairman, your question was in the context of DARPA. I might say that from my experience in the Department of Defense, there are applications of large computers which, because of classified levels, I cannot go into at this point. But the point of my comment is those that I am familiar with from the past do not have that kind of overlap purpose that you are concerned with. But we understand what you have said and will certainly continue to be sensitive to it.

Mr. GLICKMAN. Thank you.

Mr. Carney?

Mr. CARNEY. Thank you, Mr. Chairman.

Welcome, Dr. Martin. I enjoyed your testimony.

You say that the program for propfan is targeted at $126 million?

Dr. MARTIN. That would be the overall cost over——

Mr. CARNEY. Many years?

Dr. MARTIN. What is it, 4 or 5 years?

Dr. COLLADAY. Yes, and that is just the flight phase on top of the base technology that is also on the order of $100 million that is in the budget for fiscal year 1983–84.

Mr. CARNEY. How much have we spent so far?

Dr. COLLADAY. On the order of $50 million through fiscal year 1984, sir, since the mid-1970's.

Mr. CARNEY. Then there is $11 million in this budget, and we didn't get $25 million for the flight phase. Am I looking at it the same way you are?

Dr. COLLADAY. Yes, except you mentioned $11 million, and it is $14 million.

Mr. CARNEY. I am sorry, $14 million, and then the $25 million would be the flight phase. Would you suspect the program would become so stagnated if we didn't go into the flight phase that it might be dying a slow death?

Dr. COLLADAY. Sir, we are proceeding with the moneys appropriated through 1984, with a commitment to proceed on the path to an eventual flight phase. We are at that point where we are prepared and planning in fact to award some major systems contracts that would eventually lead to a flight phase, so that we can keep that option open and not lose schedule slippage in the event of a budget that could support the flight phase in 1986 or out years.

So we are pursuing a program in 1984 to preserve that option.

Mr. CARNEY. But in 1985, are you going to pursue a program that will——

Dr. COLLADAY. In 1985, with $14 million as proposed in the budget, we would pursue those paths. We would not terminate anything that was started in 1984 and commitments that were made, but we would have to slow up the schedule. It would slip. The flight test that we have indicated to you previously as occurring in 1987 would require the additional $25 million. That was consistent with the program that was submitted.

Mr. CARNEY. So it will slip a year before flight phase?

Dr. COLLADAY. In 1985, we would begin to slip a year at a time in the flight phase, that is correct.

Mr. CARNEY. Slipping a year would increase the price of the overall program. Isn't that correct?

Dr. COLLADAY. To the extent of inflation, that is true.

Mr. CARNEY. And we would have had $74 million into the overall program, and we are going to just push it back? I don't know if that is prudent management to allow that to happen. I mean, we have such a commitment out there now in dollars and time. To allow it to slip, I am not so sure that that would happen.

Dr. Colladay, in view of what you had said before about the risk factors involved in it, that you believe that there should be a strong NASA role, I was perhaps going to question the other way, wondering—the benefits that could very well come out of that program are so great to the industry. I didn't think that the factors of return were the same as you seem to think.

I don't think I made myself clear with that statement. What I am saying is that you—it has been a long day. I got at my desk at 7 o'clock this morning, and I am not used to it. It feels like it is about 6 in the afternoon.

You said that NASA has a role here because of the risk factor. The industry recognizes the enormous benefits from what is perceived to be the benefit from this new approach as far as fuel savings, that type of thing. Doesn't that diminish the risk factor if the benefit is greater?

Dr. COLLADAY. Only if it pays off, but there are enough technical uncertainties that the industry is not prepared to take that step without drawing on NASA's support. I would add that that support is far more than resources, dollar resources. It is expertise in the way of manpower at our centers that have the capability of evaluating and designing these advanced blade configurations as well as the facilities that we have.

Mr. CARNEY. OK, that is good. Now, my point is this: Let's spend a little money now and find out those questions, the questions about risk, whether it will work or not. If we think it is not going to work, let's come back to us next year and tell us it is not going to work. We will drop the whole program.

But to keep delaying it and just spoon feeding in a little bit of money, that doesn't seem like prudent management of a program. How long will it take us to make a determination whether the risks are worthwhile or not for industry?

Dr. COLLADAY. Sir, I don't believe that that question can be answered until we carry the high-speed propfan to flight test.

Mr. CARNEY. What you are telling me is we should do that immediately, then. We are looking at a benefit of maybe $1 a billion annual savings in fuel costs to the aviation industry, to say nothing of what that would mean to fuel economies in our overall economy and our strategic position. Why, then, did NASA push it off a year? Might it be they strongly believe we are going to put it back in the budget?

Dr. MARTIN. It was pushed off, Mr. Carney, as we said, by OMB, not by NASA.

Mr. CARNEY. Yes, but I would suspect that you would have a pecking order, and OMB would come in and cut and say, Well, you know, you have a very energetic program here, Dr. Martin, but, you know, we can only tolerate so much money under the present

budget scenario, so we are going to take—they must have had some type of interface with you on programs that have priority.

Dr. MARTIN. Unfortunately, not with me, sir. That was all cut and dried when I got there.

Mr. CARNEY. I appreciate that. In fact I said in my opening remarks.

Dr. MARTIN. Yes.

Mr. CARNEY. But, Dr. Colladay, why was that program that has such great benefit so low on the pecking list?

Dr. COLLADAY. It was the highest priority program in aeronautics. That is all I can say, sir. From the agency standpoint, advanced turboprop was and still is our highest priority aeronautics program.*

Mr. GLICKMAN. Let me just ask him, how did it rank overall?

Dr. COLLADAY. It was very high also in the agency's priorities overall.

Mr. CARNEY. I think what they are probably waiting for is for us to put it back in, but again, I think, as the chairman suggested, we are going to have to sit down and do some talking.

Going from one program to another if I may, I would like to talk about lightweight diesel aircraft engines if I can.

We have had an ongoing program with this, and it is my understanding that you may withhold—I haven't had a chance to look at the budget line by line—but almost $500,000 of funds that were already appropriated by Congress in the area of lightweight diesel aircraft.

Is there any validity to that rumor?

Dr. COLLADAY. No, sir. As you know, since 1979, we have been pursuing in the R&T base under propulsion two lightweight engine system concepts for general aviation: one, the diesel program that you mentioned, and the other, rotary engine. The plan has been to carry both of those activities along to a decision point in fiscal year 1985 and make a determination at that time which one we should put our resources on to carry into an engine system effort, carry on beyond 1985.

That issue is still open, and we intend to fund both concepts, the diesel and the rotary, to that point as originally planned.

Mr. CARNEY. Thank you.

I am wondering if I should swing back to the propfan again, in my mind. Let's move off of propfan for a moment. My mind keeps going back to that, I must admit.

How does the ATOPS program at Langley differ from the flight management research program at Ames?

Dr. COLLADAY. The ATOPS program is directed at transport aircraft interfacing in the air traffic control system, and those interfaces are very important when you are dealing with advanced guidance systems and display and human factors.

I am not sure—the Ames program, the flight management program at Ames, if you mean the flight program at Dryden or if you mean the——

Mr. CARNEY. The flight management research, the ground control program, one being, as I see it, a cockpit program or flight sim-

* Dr. Colladay meant to say it was the highest priority program augmentation in aeronautics.

ulator program; the other one, the air traffic control, human factors program.

Dr. COLLADAY. Well, they are closely coordinated. A lot of the basic human factors work through the new facility at Ames, the manned vehicle research simulator that is operational now, is looking at some of the fundamental research aspects of human factors in current and advanced cockpit.

The advanced cockpit simulator in that facility at Ames is—we have a similar one at Langley to make sure that the two programs are coordinated. They are not duplicative. They reinforce each other. The ATOPS is the flight simulator similar to the ground-based facility at Ames.

Mr. CARNEY. My concern—and you answered that, of course—was the coordination between the two programs, and obviously, you are watching that carefully. It is an integrated program.

Dr. COLLADAY. Yes.

Mr. CARNEY. Do airline pilots participate in either the ATOPS program or the flight management program at Ames?

Dr. COLLADAY. I know personally that they participate actively in the simulation research at Ames, in the human factors. We have a number of simulators, and we have pilots, airline pilots, coming in, as well as air traffic control operators, to reproduce a realistic simulation.

I cannot answer the question in regard to ATOPS at Langley, but we can certainly get that answer for you.

Mr. CARNEY. I would appreciate that.

[Material to be supplied follows:]

A principal goal of the ATOPS program involves the use of advances in technology to evaluate new concepts in transport aircraft flight station design. Fundamental to an effective flight station configuration is the careful consideration of crew roles and performance as affected by design. The extensive use of highly flexible display devices and the powerful onboard computers provide an almost unlimited range of alternatives in establishing the role and tasks of the pilot. Therefore, it is imperative to assess the impact on crew performance of various alternative display devices, formats, procedures, and control devices. The ATOPS program uses airline pilots and research pilots at several levels. First, in the planning stage, NASA's Aeronautical Advisory Committee includes airline pilots among its members. An example of airline pilot participation at the next stage was seeking the advice of the Air Line Pilots Association's All-Weather Operations Committee at a soft mockup of the Advanced Concepts Simulator of crew systems and flight station concepts for a 1995 transport aircraft. Piedmont Airline pilots participated in pilot eye scan pattern measurement task. Nine Piedmont Airline pilots flew more than 400 approaches in the ATOPS 737 aircraft in a joint program between NASA and FAA in a study of MLS complex approach paths. United Air Line pilots have been involved in our profile descent research. In another activity three pilots from three airlines participated in a joint NASA/FAA runway traction research task involving the ATOPS 737 aircraft.

Mr. CARNEY. What is the FAA's involvement in these programs, if any?

Dr. COLLADAY. They are very heavily involved in the whole program, both that at Langley and at Ames.

Mr. CARNEY. How about funding?

Dr. COLLADAY. The research that we do in the aircraft side of the interface with the air traffic control system we think is NASA's responsibility, and we plan and coordinate with the FAA, but we fund. There is very little reimbursable funding from the FAA in aircraft research.

Mr. CARNEY. How about on the program at Ames, then?

Dr. COLLADAY. Well, inasmuch as we are not looking at human factors of air traffic controllers but rather in the cockpit, the same thing holds at Ames.

Mr. CARNEY. Thank you very much.

I will slide right back for just a moment on the propfan. I know I have abused my time here, so I want to give my other colleagues some time to ask questions as well, but is the single rotation propfan the best way to show the proof of the concept?

Dr. COLLADAY. Well, it is the best way to answer two of the critical technical questions that we are facing, and one is blade/air elasticity, that you would like to have a relatively clean inlet of a single propeller mounted on the wing in a tractor configuration.

That will not necessarily be a proof of concept of the—and I would underline "the"—configuration that the industry might choose to go into development on, because we are not looking, we are not trying to address the best configuration with that; we are trying to answer some fundamental technical issues on blade structure, flying at mach 8/10 in a large enough scale that we can calibrate our small-scale models.

Those are the issues that need to be addressed, and I think the single-rotation configuration is the best one to do that research on. That is only one of the technical questions that needs to be addressed, however. There are other elements of the technology base that need to be in place if industry is to be able to sort their way through this maze to make the kinds of decisions that they will have to make in the late 1980's if they want to go into development with it, and that is gearbox technology, configuration studies that look at not only the wing-mounted tractor but aft-mounted pusher configurations, counterrotation, a number of engine system technologies that also need to be pursued.

We are trying to look at that broad scope program and address what we think are the potential show stoppers that we need to address, to answer. But in terms of the flight program right now as we see it, you would like a fairly clean configuration of a wing-mounted single rotation.

Mr. CARNEY. One last question, and you can answer it very briefly, please.

Do you follow industry's input into this program, how much money they are spending, how much time and research that they are doing on their own in propfan?

Dr. COLLADAY. Yes; we do, sir. I think the program we have and have been pursuing since the mid-1970's in turboprops has spawned parallel activities in industry that are all part of the same thrust, and I think it is well planned and we understand what they are doing.

Mr. CARNEY. Could you give us an idea of how much money they have spent?

Dr. COLLADAY. I would have to supply that to you. I cannot, off the top of my head, give it to you, but I could in rough ball park numbers.

Mr. CARNEY. Thank you, doctor.

[Material to be supplied follows:]

Industry development, including Independent Research and Development (IR&D) funding, for advanced turboprop research and development totaled approximately $53 million from 1978 through 1983. During this same timeframe, total appropriated NASA funding for the Advanced Turboprop Systems Technology program totaled $36.3 million.

Mr. CARNEY. Mr. Chairman, thank you for your indulgence.

Mr. GLICKMAN. You are welcome.

I am going to recognize members as they came in this morning. So, Mr. McCandless, and then I will get to Mr. Dymally.

Mr. MCCANDLESS. Thank you, Mr. Chairman.

In reviewing the information that was made available to us, line item numbers to be allotted to this based upon the final budget approval, one's mind wanders back to his previous experience with the private sector, and I am wondering, in an overall nuts-and-bolts question, what type of cost-control auditing goes into—for example, let's take one of the things that was talked about earlier by my colleagues, the intermittent combustion engines for small aircraft, which your handout talks about the objective of reduced fuel, weight, and higher altitude capability with also fuel flexibility.

In developing a program like that or any other program, how is management satisfied that they are getting the biggest bang for the buck that goes into that particular program?

Dr. MARTIN. I am not sure, Mr. McCandless, that I understand what the essence of the question is. Is it one of trying to understand how we get the greatest return on investment for the research funds that we are——

Mr. MCCANDLESS. Let me restate the question, because my question could be interpreted different ways.

The propulsion program for this general aviation is proposed at $22[1] million. In the department that is directly responsible for that program and the expenditure of that fund, what type of administrative audit on a day-today, week-to-week, month-to-month basis, takes place to assure or to try to assure that that $22[1] million is being spent in that program to the best degree possible?

Dr. MARTIN. I see. There is an elaborate, I would say, consensual process that goes on that involves people at the headquarters where Dr. Colladay and I work, in the research and other laboratories, but in the research centers, expression of views of the merits of this allocation or that.

There is an advisory process or an advisory apparatus which one might say is very robust with respect to the various kinds of disciplines that we get into, so that each of those disciplines gets a good "scrubbing," if I can use that word, with respect to priorities within a narrow area such as propulsion, say; and there is a hierarchy of advisers that then melds the views of the individual specialties or disciplines that were on the board half an hour or an hour ago, to make sure that there is then an integrated view of the apparent priorities.

We have numerous conversations with people in industry who express themselves on their views of the proper ways—and I must say that is to some degree subjective, but the optimum way of

[1] This figure is in error. The actual budget proposal for general aviation propulsion is $2 million.

making expenditures in research in various areas. So it is a very large and elaborate and continuing consensual process that is rarely quantified but in which—and I am really talking about Pentagon experience now, not NASA experience—but after you have gone through it for a while, you begin to build the confidence because it is so highly ramified and people are so well informed and communicate so intensively and so frequently that there is little doubt about who believes what and what the consensus is in that process.

I hope that addresses your question. It is not a quantified thing in that anybody talks about return on investment or discounted cash flow and all that. That doesn't very often come in.

Mr. McCandless. The other aspect of this is that it seems to be a common demoninator within the structure here in Washington that we are all as efficient as we can be at the current level, and therefore everything that takes place in the way of funding a program, a project, or a department could not be done any more efficiently, because we don't continue to review whether or not we have reached or can improve the basic efficiency of the department.

That was kind of what I was getting at. The other aspect of this is that we also tend to say, Well, due to inflation, we are going to have to ask for additional money in order to conduct the same level of activity, whatever it may be, yours or someone else's, and there never appears to be any kind of a direction in that society has made us more efficient because we have a higher speed computer or because we can make phone calls in a shorter period of time due to a better phone system, and therefore we do not need the inflation because the scenario under which we work is more efficient.

These things probably are more general in nature than they are to NASA, but I am sitting here in an appropriation recommendation mode, and you are the one out there, and this is the only chance I get to discuss this with people like you. Do you have any comments about these things?

Dr. Martin. Yes, sir. It is certainly true that any given group of people, in my experiences both in government and industry, always feels they are overworked, and they wish they had more time or more resources to do the job at hand.

That must be the American way; I don't know. But it is everywhere in government, in my experience, and in industry, as it happens. That is not to say that we shouldn't look for efficiencies; in fact, Mr. Beggs has made productivity and quality enhancement a thrust of his, a goal of his, for improvement in NASA during this year and this epoch, so that we are conscious of those needs to work smarter, not harder; let me put it that way. We are trying to do those things. We are trying to figure out ways in which we can be more productive, do all the things that are necessary and more with the people that we have.

So we are conscious of those kinds of things. Now, there is, at least in one avenue of the science and engineering work that I am familiar with, if you buy a bigger computer, you will always use it fully in a very short time—that is a law of nature—and then you will need another one. I think there is some element of the imagination of people being constrained to some degree by the capabili-

ties that they have around them, and if you offer them more capabilities, then they will become more imaginative and more productive, but in a different way.

So I think that the notion of productivity and quality enchancement can be looked upon in two ways, one with fixed resources in which you try to do more with what you've got or expanding resources in which you change the quality or the nature of the work that you are doing, and that frequently happens in science and engineering.

Now, that was kind of rambling, but I hope it begins to address what you are putting your finger on.

Mr. McCandless. Let me ask one more question, Mr. Chairman.

To get more specific and illustrative, the automobile industry, with which I was connected many, many years, found itself in a position of "We make the best and we have the knowledge," and so on and so forth, and when they finally came out of the ether, they had lost a considerable amount of their market to the foreign sector, because they went around in a somewhat vacuum and were not sensitive to what is going on around them in terms of the technology of their industry and how it could be implemented to make a more efficient product, to make the product equal in quality but less time in production because of innovative and modern techniques.

Using that as a base point, in the process here that we are talking about this morning, are we taking full advantage of what is available to us in the way of techniques, management, professional, scientific, and so forth; or are we still satisfied with certain levels of knowledge that we have within house but that in that particular field, maybe in the private sector or in the foreign markets, have gone on beyond that?

Mr. Martin. I have shared some of the experience that you have had in the automotive industry. I was associated with an organization that had a large automotive component, so I know what you are talking about. It also had a large aerospace component, I might say, as well.

This is a way of answering your question, I think. The way in which those two elements of the company faced their markets and their customers seemed to me to be very different. The automotive was characterized pretty much in the way that you said. The aerospace, I think the people in the aerospace business, but in this one in particular, tended to understand that the characteristic time for change in their business was much shorter than it was elsewhere, and they had to remain more alive to the possibilities to remain alive in the business.

So I didn't see the same kinds of—you didn't use the word "complacency," but I didn't see the same kind of complacency in aerospace kinds of activities as one saw elsewhere.

So my belief in general is that the aerospace business is sufficiently different culturally that that experience of yours and mine with respect to the automotive industry is not necessarily borne out and probably is not borne out.

Now, I don't mean to say that everything is just fine because it clearly is not just fine these days. We used to beat the socks off everybody with respect to aeronautics products, and there is plenty

of foreign competition these days, as I said during my remarks. And so it could be that there are some elements of that complacency, but I really have not been sufficiently in touch with large numbers of people in the aerospace industry during the past 3 or 4 years to make that as a firsthand statement.

But I think that in the business that we are talking about here today; that kind of difficulty is much less of a problem than it was with respect to the automotive business, as you have spoken of.

Mr. McCandless. Each of the manufacturers of airframes, of components of a major nature within the aircraft industry has a certain amount of R&D that they are doing on their own, whatever it might be. Are you satisfied that those projects and what their goals and objectives are within the framework of that company itself are being coordinated to the maximum degree possible with what you may be doing over here in NASA that might be parallel and duplicative?

Dr. Martin. Yes, sir, I think there is a pretty good process. The accessibility of NASA people in particular but I might say Government technologists in general to what is going on in industry, in the aeronautics industry, if you will, is very good. It is in the interest of all, both sides, Government and industry, for that knowledge to flow back and forth.

There is a formal process that exists. It is called—well, the proper name for it is the independent research and development process, referred to as IR&D or IRAD, which is a process in which the various industries—I hope I am not informing you on something that you are fully informed on—but it is a process on which the research funds that the various industrial concerns spend some of their own moneys—and the research results that come from that—are made known in brochures on an annual basis to the Government, in particular the Department of Defense and NASA, so that there is a document that exists for practically all of the major and maybe even a lot of the minor industrial concerns and what they are doing that is of interest in the relevant technologies that are available to us.

And so that is another documented way. NASA is essentially in the business of generating technology and making it known to people in the industry here, so that again that flow is informal and it is formal and it is continual, and I think it is pretty good. There might be ways of making it better, but I think there are very few secrets unless somebody works very hard in an industrial concern to keep it a secret.

Mr. McCandless. Are there any legal problems with the sharing of this—that is, antitrust or something like that—which tend to find their way into other industries when it comes to technology sharing?

Dr. Martin. I will defer to Dr. Colladay in a moment with respect to NASA. I cannot imagine that there is any conflict with NASA. There certainly are potential conflicts if industrial concerns get together and generate technology to the exclusion of others.

In fact, recently in the electronics industry, a committee called MCC was formed just for the specific purpose of permitting electronics industries to get together and to cooperate in their research and to share in the benefits. I think they worked hard to make

sure that they didn't have conflict of interest, but I think that there is a dawning awareness that consideration needs to be given to that topic of cooperating and sharing without getting into the antitrust kinds of things, and I think this Nation will probably do more and think more about that subject in the future, for the reasons that you probably have in mind.

Is there any problem?

Dr. COLLADAY. No; I don't have anything to add.

Mr. MCCANDLESS. The reason I brought this up, it is my understanding that where we are beginning to fall behind in certain technologies, to our detriment, with respect to another nation, we have had legal problems within the framework of that industry in trying to share the technology and to work together to produce a total better product that is not experienced in our competitor's country, separate from any governmental subsidy or overseeing of financial capital.

That is why I asked the question, because we can do all kinds of research out here in one area, but if we cannot implement that research for the good of the total industry because there is some kind of legal framework preventing it, and our competitors are able to do that, that places us in a somewhat compromised mode when it comes to the total result to try to keep ahead.

Dr. MARTIN. Yes, sir.

Mr. MCCANDLESS. Thank you, Mr. Chairman.

Mr. GLICKMAN. Thank you, Mr. McCandless.

Mr. Dymally.

Mr. DYMALLY. Thank you, Mr. Chairman.

Last year I think we gave you $10 million for the propjet. Did you spend it?

Dr. COLLADAY. It is being applied in fiscal year 1984 to the elements of the program that I referred to earlier, the large-scale effort in the design and fabrication of the large-scale 9-foot diameter propeller and the contracts that will be awarded within the next several months for the test of that aircraft's initial design, the modifications that need to be made, as well as some engine system tests or research on advanced concepts, and the continuing wind tunnel tests of the 2-foot diameter models. Yes; we are.

Mr. DYMALLY. If you are given the money that you need to continue the work, would you be able to spend it?

Dr. COLLADAY. We wouldn't have any trouble spending it, sir. We have laid out a program that would pursue the technology paths that need to be pursued. We would, of course, spend the resources that were appropriated.

Mr. DYMALLY. Thank you very much, Mr. Chairman.

Mr. GLICKMAN. I want to just go back again to this problem of propfan.

Dr. Colladay, you kind of, at least initially, didn't seem to be too enthusiastic about some form of cost payback by industry, not necessarily a cost sharing right now—perhaps that, but a cost payback at some point in time in the future.

Have you ruled that out?

Dr. COLLADAY. Well, I cannot say we have ruled it out, Mr. Chairman. We have taken the position that the technical risks are sufficiently high that it would be appropriate for the Government and

NASA to carry it to a point where some of those technical questions have been answered before I think industry would be willing to sign up for a payback on a product that they don't know that they can even develop yet. If that were a possibility, we would certainly pursue it.

Mr. GLICKMAN. I am going to suggest that to industry. You know, I wouldn't rule this out. That is why I am not saying cost sharing, necessarily. That implies the technical risk is completed, which it is not, but if there is no product, there is no payback. It is as simple as that. It is just a possibility that you ought to consider, industry ought to consider, and we will in terms of our proposals here.

Let me ask you just a couple of related questions before we go.

I am concerned about general aviation, that it does not get a very—has never really gotten a very significant part of the NASA aeronautics dollar.

During our hearing in December, we had a gentleman from Beech Aircraft—Chet Rambleske was his name—and he talked about this a bit. There have been some recent advances in some of the new designs using composites at some of the companies, but fundamentally, there has not been any dramatic change in the type of basic, single-engine, general aviation aircraft offered in this country for a long time, and it looks to me like you are asking for $5.2 million in fiscal year 1985 for general aviation and commuter aviation, which is roughly a $400,000 increase over the previous year.

Are you reexamining your role in general aviation to see if there is some way that you can enhance that more aggressively?

Dr. MARTIN. I am going to let Dr. Colladay answer that, but the answer for me is certainly yes. My impression is—well, the fact is that I am not very well informed on the general aviation industry, and I feel that I must be.

From the few conversations that I have had, I have the understanding that the attitude or relationship in general between general aviation manufacturers and NASA has been of a different nature than that of the large transport manufacturers, and it might be just a matter that we didn't make adequate efforts to make known to them what we are doing and what we could do with them or for them.

If that is the case, then I know how to fix that. If there are other problems, I will have to discover them, but certainly my attitude is one of embracing that particular part of the industry because——

Mr. GLICKMAN. Needless to say, their sales have not been very good the last 12 to 24 months, and I just think that it is a major part of the U.S. aerospace industry, general aviation. I am not going to say it has been neglected by NASA. I am also not going to say that in some cases maybe the industry itself has not been as aggressive as they should have.

But if you read Rembleske's testimomy, you get some ideas on where he at least thinks that NASA ought to be going in the general aviation area.

Do you have any additional comments, Dr. Colladay?

Dr. COLLADAY. Well, I have noticed just recently the general aviation industry has exhibited a lot more readiness to apply ad-

vanced technology, which was one of our problems, has been one of our problems historically, of getting the technology that is developed of a more generic nature and get it applied to general aviation vehicles.

We are concerned about that element of the program, as Dr. Martin said, and we have asked the Aeronautics and Space Engineering Board of the National Academy specifically to evaluate the program that we do have in place that supports general aviation, not just the $5 million that you indicated, but also the generic, the part of the generic program that is applicable to it, and see what we might do, and help us and advise us in what we might do to improve and enhance our support to that sector.

Mr. GLICKMAN. One final question from me, and that concerns the wind-tunnel problem out at Ames. You talked about $26.5 million budgeted to fix it.

I think that was a major embarrassment for NASA that that thing occurred. I wonder what projects have been impacted by that, and have they been able to work around the delay? That is my first question.

My second question is, what management changes have you instituted as a result of that accident?

Dr. MARTIN. I understand the seriousness of that problem. In fact, I have asked Dr. Colladay to be a kind of personal representative of mine with respect to the 40 by 80 by 120 to assure that all the things that I said to you about the repair project being on schedule and on cost remain that way, and I will leave it to him now to tell you the details of that.

But it has caught my attention and it is going to remain in my attention.

Mr. GLICKMAN. All right.

Dr. COLLADAY. I share your feeling that it was an embarrassment to the agency and to Ames; it was. We are treating it very seriously, not only directly related to that project but lessons learned on what we can do to prevent it from ever happening again.

We have worked around the schedule impact, and by moving tests to other wind tunnels, I think we have accommodated—while there has been a hardship, we have accommodated that schedule slip reasonably well.

Other programs that have been impacted: There have been, most specifically, the 12-foot tunnel CofF project, that was in the 1982 appropriation; we used the resources that were appropriated for that tunnel through the emergency repair authority of the Administrator to apply to the repair of the 40 by 80 by 120.

We are looking at what we do with the 12-foot tunnel in terms of whether we come back to the Congress for new authorization or appropriation authority. If we intend to do that, it will be in a future budget year and it will be prioritized and competed.

Mr. GLICKMAN. What about research projects that have been delayed, though, like JVX? Any work on that? The tilt rotor? Have you had to slip some of your actual testing?

Dr. COLLADAY. I think we have accommodated those slips, as I said, by working through other tunnels, the 30 by 60, for example, at Langley, and we worked very closely with the JVX project to make sure that we could accommodate their schedule due to the

slippage, and I think at this point we have managed to work around reasonably well. There has been an impact, but with the other tunnels that we can use, I think we have it reasonably well worked out.

Mr. GLICKMAN. All right. Now, what about my question on management changes? Have there been any instituted as a result of the accident?

Dr. COLLADAY. Yes, sir, there have been a number of them at Ames, in particular, and special oversight functions that have been set up to not only address the long-term and continuing nature of the problem but specifically the repair itself.

A new project team was established that reports directly to the center director; a new project manager; beefing up of the engineering services group that has to provide the oversight; and a third party, separate oversight group that also reports directly to the director.

The safety functions at the laboratory have been beefed up. OAST in headquarters has set up an oversight group that is chaired by the chairman of the Accident Investigation Board, and that committee reports directly to Dr. Martin.

There have been a number of institutional and specific oversight functions that have been put in place to insure that it doesn't happen again and that we can complete the repair project on cost and on schedule.

Mr. GLICKMAN. A final question, and then I will see if anybody else has anything.

You know, in my opening statement, I made the point that the Aeronautical Policy Review Committee found that the current R&T efforts are not consistent with the bold spirit of the administration's aeronautical R&T policy.

Dr. Martin, do you think that this proposal that you have given us is in fact consistent with bold leadership in aeronautics?

Dr. MARTIN. Probably not in the sense that that committee had in mind when they made that report, Mr. Chairman. I would have to be candid and say that.

The present proposal is not a discontinuous change with the past, and I think that in the sense that I read that report, it was a virtual turning that was being sought and talked of in there. And so, to that degree, I would say it is probably not what they had in mind.

Mr. GLICKMAN. Any further questions? Yes, Mr. McCandless.

Mr. MCCANDLESS. Just one if I may.

Mr. GLICKMAN. Sure, Mr. McCandless. Go ahead. I will be happy to yield to the good-looking fellow from California.

Mr. MCCANDLESS. We have a budding pilot on the staff who is a very avid reader about aviation, and she said a recent general aviation publication did a report on the Cessna 172, in which they said the Skyhawk fits like an old shoe, but who wants to buy an old shoe at today's prices?

They went on to say that general aviation airplanes are technologically stagnant and represent forties and fifties state of the art at today's prices, and that they compare to paying $10,000 for a 1973 Chevrolet.

My question is, What responsibility does Government have for private general aviation? The chairman alluded to this, but I think he is a little biased, being from Wichita. [Laughter.]

I say that in a sense of——

Mr. GLICKMAN. Fondness, right?

Mr. MCCANDLESS [continuing]. Fondness.

Mr. GLICKMAN. Yes, OK. [Laughter.]

Mr. MCCANDLESS. Do we have a responsibility, in your opinion, for general aviation of this type?

Dr. MARTIN. I think I have a very mixed answer to that, Mr. McCandless.

Mr. MCCANDLESS. I left the door way open; you can walk either way.

Dr. MARTIN. Yes. To the degree that general aviation wants to be helped, I would say yes, that we have an obligation to understand their needs and, within the resources that are available to us and the guidance that is given to us, that we have that responsibility.

If, on the other hand, it means do we have to go out in the bushes and beat up on them and tell them they've got to take this and do something with it, I would say no, and it would be probably not in the spirit of the way a capitalistic society runs for the Government to do that to its industries.

So I think we could coax and cajole and try to help that way, at the very most, but I wouldn't want to see the Government become too heavyhanded in trying to help industry, because it could be something that wasn't wanted.

Mr. MCCANDLESS. And why should we take time and research and the taxpayers' money for general aviation propulsion technology? Why not let the current suppliers of aviation engines for general purpose aviation, let them do the research. Why should Government be involved in it?

Dr. MARTIN. I think it probably is for the reason that the amounts of investment that need to be made—pick an engine, for instance—the amount of investments that have to be made have too great a value, too great a present value compared with the present value of the possible sales if the engine pays off, that it isn't a good risk for the industry to do it, so that unless there is some major technological change which really looks as if the general aviation airframe manufacturers will get back a disproportionate share of the market by exploiting the technology, then I think they just wouldn't do it, and it is for that reason, I think, that we have to help them, because they won't be helped otherwise.

Mr. MCCANDLESS. Well, we could draw some kind of a parallel, then, going back again. Your objectives here are reduced fuel, weight capability, and fuel flexibility. One could take those same goals and say: "Well, let's do it to the automobile industry; let's do it to the housing industry; let's let Government get involved in all the research and development of these various facets of major components of our society as far as industry is concerned."

I guess I am getting a little philosophical here with NASA, but at what point does Government have a responsibility?

Dr. MARTIN. I think Government has a responsibility, Mr. McCandless, when the Congress passes a law that says that there is an agency that has the responsibility to do those things.

Mr. MCCANDLESS. Good answer. Excellent answer. It all starts here, doesn't it?

Dr. MARTIN. A lot of it starts here, sir. [Laughter.]

Mr. MCCANDLESS. Thank you very much. I appreciated your presentation, and I liked the format of your presentation. It was very easy to understand and to follow.

Dr. MARTIN. Thank you.

Mr. MCCANDLESS. Thank you.

Thank you, Mr. Chairman.

Mr. GLICKMAN. Mr. Carney?

Mr. CARNEY. Mr. Chairman, after Dr. Martin so ably answered the question of my colleague from California, I don't really want to ask him too many questions.

Dr. MARTIN. I am not a wise guy, Mr. Carney. [Laughter.]

Mr. CARNEY. He clearly pointed out that the buck stops right here.

But, you know, that brings something to mind, that the buck does stop right here. If I may, what the chairman was saying before about the lack of boldness in innovative programs has a lot of merit, and certainly I feel the same way, and he has a lot of support in his views.

Let me quote something from an article in the Los Angeles Times, if I may.

Mr. MCCANDLESS. A California paper.

Mr. CARNEY. I know, and I don't know if we can trust it.

It says,

> I see a hardening of the arteries over there, a kind of Bureau of Mines mentality setting in, said one technically trained official who deals with NASA. "To me it is clear that NASA is losing its innovative thrust. Where it was once the moon and the stars, now it is technology transfer, with programs that are directly beneficial to the public, just to satisfy the White House and the Congress," a NASA official complained.

I would like to point out that the date of that article was November 27, 1977. The article goes on to state,

> The President, like Congress, has openly urged NASA to concentrate on exploiting existing knowledge rather than exploiting new knowledge.

I think this administration is trying to turn that around. We hear Jay Keyworth, and he is like a broken record talking about that.

What I am just trying to point out is that we, including myself and the chairman and everyone on this committee, strongly suggested to you last year to support the propfan, a near-term type of program, and we are doing it again this time.

So we cannot really come out and criticize your agency too much about that lack of boldness, when we, with every chance we get, try to direct your energies in areas that we think are important. We have to assume some of the responsiblity for eliminating the lack of boldness.

Now, that is a confession, and I seldom do that.

I yield back the balance of my time.

Mr. GLICKMAN. Thank you for that religious performance.

Mr. CARNEY. Sing hallelujah.

Mr. GLICKMAN. Dr. Martin, we want to thank you for excellent, candid testimony. I want to tell you, you passed your test the first

time before this subcommittee, and we are appreciative of you and Dr. Colladay being here.

Dr. MARTIN. Thank you.

Mr. GLICKMAN. The hearing stands adjourned.

[Whereupon, at 11:55 a.m., the subcommittee recessed, to reconvene at the call of the Chair.]

[The prepared statement of Dr. Martin follows:]

HOLD FOR RELEASE UNTIL
PRESENTED BY WITNESS
FEBRUARY 9, 1984

Statement
of
Dr. John J. Martin
Associate Administrator for
Aeronautics and Space Technology

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

before the

Subcommittee on Transportation, Aviation
and Materials
Committee on Science and Technology
House of Representatives

I am pleased to present to you today NASA's FY 1985 Aeronautical Research and Technology (R&T) budget request. Although this is my first meeting with you as Associate Administrator for Aeronautics and Space Technology, I have had a substantial interest in NASA's research activity for many years. During my time as Assistant Secretary of the Air Force for Research, Development and Logistics, I was aware of the considerable importance of NASA programs and the resulting technology contributions to both civil and military aviation. And as I am acquainted with the Government budget process, I know that the support and guidance of this Subcommittee have been and will continue to be vital to the success of these activities.

The United States has been preeminent in aeronautics for a number of reasons. Superior technology has been a major factor. Another factor has been that our industries and the DOD have been very imaginative in applying advanced technology to products that fill market needs. Further, our own large domestic markets have supported high U.S. production volumes, providing advantages of scale in manufacturing economy and product in-service support.

As foreign competitors and their governments become more strongly committed to increasing their penetration of civil aircraft markets and as these foreign sales continue to grow more rapidly than our domestic market, some of the U.S. advantages are being eroded, with the consequence that the importance of superior technology is becoming greater than ever. With respect to national defense, the increasing technical sophistication of our potential adversaries demands that we continue to generate new and superior aeronautical technology to provide options for future military aircraft and missiles.

In assuming my new responsibilities, my objective with respect to aeronautics is to see to it that NASA maintains and intensifies the high-quality research effort required to provide that superior technology now and in the future, and that we continue to have your support by doing so as competently and efficiently as possible.

We have constructed a well-balanced program for FY 1985 which includes a solid base of fundamental research in the aeronautical disciplines and systems research directed at the interactions of disciplines, components, and subsystems. This program will continue to provide, I believe, the technology advances critical to the continued preeminence of U.S. civil and military aviation.

The FY 1985 Aeronautics Research and Development (R&D) budget request is shown in Figure 1, compared with the previous years' budgets. The total request for FY 1985 is $342.4 million, which reflects a 13 percent increase relative to FY 1984. A breakdown of the FY 1985 R&D budget request by technical area is shown in Figure 2. Of the requested $40.1 million increase, $23.5 million is requested for a planned buildup in Systems Technology Programs for Advanced Composite Structures and for Numerical Aerodynamic Simulation (NAS). An additional $10.0 million is needed to respond to the Defense Advanced Research Projects Agency (DARPA) request that we initiate testing of the X-Wing concept on NASA's unique Rotor Systems Research Aircraft (RSRA) by the end of FY 1985.

A breakdown of the total Aeronautics-related budget request is shown in Figure 3, including $30.3 million in Construction of Facilities (CofF) funds for construction of the NAS Building at Ames Research Center and the enhancement of the 8-foot High Temperature Structures Tunnel at Langley Research Center to allow for testing of hypersonic scramjet propulsion systems. The Research and Program Management (R&PM) funds of $314.4 million are to support the aeronautical institutional requirements primarily at the three NASA Research Centers - Ames, Langley and Lewis. A breakdown of the R&D budget request by Center is also shown.

In addition to the highly specialized technical staffs and facilities at the Research Centers, our programs involve considerable industry and university participation as shown in Figure 4. This participation is essential to NASA's understanding of system requirements and integration problems and affords industry with the earliest possible economic opportunities to consider new technologies for incorporation into vehicle designs. We are striving to strengthen these relationships, and in this regard, we

are paying particular attention to the Office of Science and Technology Policy recommendations relative to early, effective dissemination of technology within the U.S. community prior to eventual unrestrained and widespread dissemination. Further, we are increasing our activity in acquiring, assimilating, and disseminating unclassified technology information available from non-United States sources to our nation's researchers.

I will now address selected areas of activity in a format that addresses the key technology "drivers" influencing our program. These drivers represent areas where substantial payoffs can be made through advances in technology and consequently serve to offer direction and focus to our activity. Today's modern aircraft, and even more so tomorrow's, can be seen as the result of integration of technologies in four key areas: aircraft structures, aircraft aerodynamics, propulsion, and flight controls. I will discuss each of the key drivers and some related programs in these areas and then discuss two vehicle-specific areas of OAST research, namely rotorcraft and high-performance aircraft.

Advances in Aircraft Structure

Advances in technology for aircraft structures are driven by the increasingly competitive need for both performance improvements and reduced costs, Figure 5. A major driver is aircraft weight reduction. Lower aircraft weight reduces fuel used and, therefore, lifetime operating cost; or it offers the opportunity for substituting increased payload for vehicle weight saved. One program directed at this goal is the Advanced Composite Structures Technology (ACST) program, Figure 6. This program was initiated last year to provide composite primary wing and fuselage structures technology for large, transport-type aircraft by the 1990's. Experience gained in past research on composite secondary components indicates that the use of composites in primary structures can reduce the weight of primary components by 25 percent and result in a 15 percent weight reduction for the total aircraft.

These previous programs involving technologies critical to wing and empennage-type structures have led to the present confidence to move into the design, fabrication, and test of intermediate-size wing-box sections. Programs under contract with Douglas Aircraft and Lockheed - California will develop the technology on straight- and swept-wing box components.

Continuing NASA in-house research at Langley Research Center is providing considerable insight into the design issues and technology needs of thin shell, pressurized, fuselage structure. The ACST program will further mature this technology with three contracted programs (Lockheed, Boeing, and Douglas) to establish preliminary

designs, assess critical design issues, and broaden the data base with small-scale tests. An effort with Boeing will extend the technology through the design, fabrication and test of large fuselage quarter-panel sections.

Another key driver, improved manufacturing techniques and processes, can provide both lower costs and greater performance for aircraft structures. Refined manufacturing procedures and increased automation have the potential to reduce the cost of fabricated parts, and advanced processing techniques can provide quality structural materials with increased capability.

One program in this area is our activity at Langley Research Center in rapidly solidified aluminum alloys, Figure 7. Recent advances in the processing of aluminum powders offer the opportunity for major improvement in strength and stiffness of aluminum alloys. By cooling molten aluminum powder at a rate greater than one million degrees per second, nonequilibrium chemical compositions can be developed offering heretofore impossible alloy compositions of considerably higher tensile strength and stiffness. The introduction of fine whiskers of silicon carbide offers even greater improvements in properties. Because the manufacturing capability for aluminum alloy products currently exists in the aircraft industry, substantial improvements can be made without retooling and without large capital expenditures.

The aluminum research program is, in addition, investigating lower cost manufacturing techniques by the evaluation of superplastic forming. This technique, which capitalizes on the ability of these alloys to be formed at low pressures into complex shapes not possible by other metal forming techniques, will allow considerable cost reduction.

High temperature materials in aircraft structures is also a technology driver offering advantage in two ways. First, such capability permits consideration of lighter-weight materials for a given aircraft operating speed, and second, it provides the opportunity for increased productivity derived from the added ability to operate at increased speeds. The program for high temperature structures combines high temperature materials technology with imaginative design concepts, Figure 8, to develop economical long-life structures operating in the 700°F to 1,800°F range.

Concepts presently being investigated at Langley Research Center include skin panel concepts for supersonic vehicles utilizing high-temperature metal alloys of titanium. Superplastic forming is used here also to permit complex, highly-efficient shapes that can accommodate the high thermal gradients encountered in

supersonic flight. The activity in hot structures is evaluating skins designed for high load and thermal stress. Research to develop an efficient structural spar web to support titanium face sheets will investigate the use of boron fiber reinforced aluminum to achieve major performance improvement.

Promising concepts derived from this work will be evaluated in the 8-foot High Temperature Structures Tunnel at Langley. This facility has the ability to simulate both the aerodynamic and thermal loads encountered in hypersonic flight. Both full-sized curved and flat panels will be tested.

Advances in Aerodynamics

The key drivers in the area of aerodynamics are shown in Figure 9. They are drag reduction, improved simulation, and improved maneuverability.

Drag reduction translates directly into fuel savings, range increases and other performance benefits. Reduced drag can potentially be accomplished by achieving large areas of laminar flow or by reducing turbulent friction. Figure 10 portrays some of the ongoing activity in this area. In FY 1985, the NASA laminar flow control research will proceed into flight tests of two innovative concepts for sustaining laminar flow with the operation of a modified Lockheed Jetstar at Dryden Flight Research Facility. Both systems, one developed by Lockheed-Georgia and one by Douglas Aircraft, will promote laminar flow while providing for removal or avoidance of harmful leading edge contamination by insects, ice formation or airborne particles. Recent discoveries in the area of turbulent flow research have lead to the development of friction reducing devices capable of reducing drag by up to 15 percent on aircraft fuselages. Two approaches -- the use of riblets and large eddy break-up devices -- will be evaluated in flight during FY 1985.

A major new facility, Figure 11, the National Transonic Facility (NTF), was dedicated at Langley Research Center on December 6, 1983. This cryogenically cooled wind tunnel will, for the first time, allow us to simulate full-scale flight Reynolds numbers throughout the transonic flight regime. The NTF will become fully operational in FY 1985 and will be heavily utilized by NASA, DOD, and industry for investigations which are sensitive to Reynolds number effects, such as configuration drag reduction. The initial research experiments will consist of an evaluation of a series of generic "pathfinder" models, which will include a supercritical-wing transport and a generic high performance military aircraft model.

Advances in numerical aerodynamic simulation, also a technology driver, will provide important savings in development time and cost for missiles and aircraft by reducing the time currently spent on experimental testing methods for new designs. The Numerical Aerodynamic Simulation (NAS) program, Figure 12, is designed to maintain the U.S. lead in aerodynamics, by providing state of the art capabilities to the research community through the installation of the most powerful computational equipment available. The NAS system, when completed, will consist of high-speed processors and four major subsystems. These are: a graphic output subsystem; a mass storage subsystem; a long-haul communications subsystem; and a user support processing subsystem. In FY 1984 the newly installed high-speed data bus for internal communications will be fully tested in preparation for the December 1984 delivery of the world's first Cray 2 high speed processor. During FY 1985, two major milestones will be achieved: the acquisition and assembly of the subsystems and the integration of the Cray 2 into the network of assembled subsystems. This network will provide the initial users with a level of computational capability not previously possible. This initial operating configuration is expected to be fully operational in FY 1986. Thereafter, continued updating of hardware and software will maintain this premier capability at the leading edge of computational simulation.

The driver of increased maneuverability provides for enhanced survivability in aerial combat situations and for more versatile weapons delivery. Figure 13 describes some of the FY 1985 activity. The broad objective of this research is efficient cruise and maneuver through the entire flight envelope for high-performance aircraft. Specific technologies are under study to increase maneuver effectiveness by improving turn radius, improving agility, and developing a high pitch angle capability. Key activities include evaluation of the aircraft system performance benefits of vortex lift augmentation by such practicable systems as vortex flaps, which control leading edge vortices (as shown at the top left) and by strakes which generate a thrust force as well as lift (shown in the adjacent sketch). Work on thrust vectoring techniques utilizing aft-mounted vanes in the exhaust for aircraft flight control will also continue. In FY 1985, the Advanced Fighter Technology Integration/F-111 will undergo flight tests at Dryden Flight Research Facility to assess active variable wing camber for increased performance and maneuverability.

Technology for Advances in Propulsion

Increased durability of engine hot sections, increased thrust/weight ratio, and improved fuel efficiency constitute the major drivers for our propulsion technology research, Figure 14.

The Hot Section Technology (HOST) Program, Figure 15, utilizes advances in materials, cooling technology and emerging computational tools, combined with advanced design and fabrication concepts, to improve engine hot section durability, life predictability and performance. In FY 1985, this cooperative industry, university, and Lewis Research Center effort will continue to investigate the combustion process in gas turbine engines, particularly the effect of multiple jet dilution mixing on flame characteristics and uniformity of combustion. Inelastic thermal-structural analysis of turbine blades under complex loading will continue. In order to validate the models being developed under this program, major improvements must be made in high temperature gas turbine instrumentation. One activity to be carried out at Lewis Research Center in FY 1985 is the development of high temperature strain gauges, which will operate and survive in the high temperature, high rotational speed environment of a turbine blade. Material behavior, and particularly the hot corrosion behavior of vane material, will also be investigated.

Ceramics offer many operational benefits to aerospace propulsion systems because of their high temperature performance capabilities. Unfortunately ceramics suffer from low reliability. The NASA ceramics research represents a long-range effort to achieve reliable and predictable ceramics by focusing on improving the understanding of the relationships between raw materials, processing variables, microstructure and mechanical and thermal properties. This research is being conducted at the Lewis Research Center, with participation by universities and the ceramics and engine industries.

The Advanced Turboprop (ATP) program, Figure 16, combines subelements of programs proposed or underway both in-house and at industrial installations in a technology-building process -- involving propfan efficiency and structures, advanced technology gears, acoustics, aerodynamic integration and innovative installation arrangements -- to take advantage of the superior propulsive efficiency of the propfan to improve fuel efficiency. The program is under the overall management of Lewis Research Center with involvement by Langley and Ames Research Centers in the areas of installation aerodynamics and cabin environment. Under the existing program, major contracts with Allison Gas Turbine, Boeing, Douglas Aircraft, General Electric, Hamilton Standard, Lockheed-California and Lockheed-Georgia, Pratt and Whitney, and United Technologies Research Center are evaluating the most critical, enabling propfan technologies for flight Mach numbers between 0.65 to 0.85.

Key technologies to be addressed in FY 1985 include: aerodynamic evaluation of the performance of the propfan engine inlet located behind the propeller, including its pressure recovery and distortion index; wind tunnel evaluation of the relative merits of single- and counter-rotation propfan models to establish the unique characteristics of each; investigation of the installation aerodynamic effects including nacelle and wing drag; airborne and structure-borne noise and vibrations from the propfan slipstream; and comparative performance of pusher vs. tractor installations. In FY 1985, preparation for large-scale ground tests of realistic propfan, gearbox, and engine-on-wing configurations will be initiated. Preliminary investigations of unique gearless, counter-rotating propfan configurations will also be conducted.

For some 40 years, the General Aviation (GA) industry has lacked the major new propulsion innovations that have characterized the dramatic military and commercial aviation growth. Improved fuel efficiency, a key requirement for GA propulsion advancement, constitutes the principal objective of the current NASA intermittent combustion rotary and diesel engine programs, Figure 17. Efforts at Curtiss-Wright and Teledyne, together with university grants and the in-house effort at Lewis Research Center, are directed at advancing the technology in a variety of areas. In FY 1985, a computerized thermodynamic engine cycle and process model for advanced rotary and diesel engines will be developed and later experimentally validated. Advanced combustion and fuel injection technologies will be evaluated in hot-firing test rigs. Advanced materials, such as ceramics, and component technologies for intermittent combustion engines will be identified after which technology validation experiments with breadboard engines will be carried out. A full-scale engine evaluation of one concept, either rotary or diesel, will be initiated in FY 1985 to demonstrate technology readiness.

Technology for Advances in Aircraft Controls

Classical aircraft controls technology provides the interface between the pilot and the airplane's dynamic response. Today's emerging digital flight controls promise dramatic improvement in performance. The goal of the NASA research is to provide the U.S. industry with the confidence in these advanced flight controls concepts. Major drivers, Figure 18, include reliability, relaxed stability and controls integration.

Research to insure the reliability of digital flight controls crucial to flight safety and dependable operations is underway. These control systems must be fault tolerant to minimize impact of local failures in the hardware or software of such systems. A significant

new facility for flight crucial controls research became operational in 1983 at Langley Research Center. Named AIRLAB (Avionics Integration Research Laboratory), Figure 19, it is being used to carry out generic research in analysis and modeling of fault tolerant concepts to predict systems reliability. In FY 1985, characteristics of system recovery from the artificial injection of component and functional faults will be studied. Models for the probability of failure of individual hardware components, as well as systems architectures, will be developed. The goal of this activity in reliability is to develop digital flight-crucial controls which will, even in the near term, be as reliable as the aircraft primary structure, and offer nearly perfect reliability in the long term.

Application of advanced control systems will allow the relaxation of natural aerodynamic stability. Such relaxed stability enables reduction in the size of tail surfaces resulting in weight savings and reduced drag. Advanced control systems research, Figure 20, will continue at Langley and Ames Research Centers in FY 1985 to enhance the development of design tools for application to control systems. These design tools, which are highly interactive computer programs, will be validated by comparing analytical predictions with results from simulation and flight test. Research is also underway to develop flying qualities criteria for future highly control-augmented aircraft.

The number and complexity of control functions in modern aircraft will require control systems integration to be truly effective. This is best done early in the design process to achieve maximum benefit. One important area of research ongoing at Langley and Lewis Research Centers is the incorporation of airframe dynamics, inlet aerodynamics and engine performance in the design of control systems, Figure 21. In FY 1985, selected systems architectures for integrated aircraft control requirements will be evaluated. Various thrust vectoring concepts will be studied in analytical and piloted simulation facilities. In addition, flight tests at Dryden Flight Research Facility will be initiated with the F-15 HIDEC (Highly-Integrated Digital Electronic Controls) research aircraft to assess performance advantages of integrating the flight path management and throttle functions for improved mission effectiveness.

Technology Advances in Rotorcraft

The objective of the Rotorcraft Technology program, under overall management by Ames Research Center, is to work with industry to advance the state of U.S. technology to meet the challenges in designing the next

generation of superior rotorcraft for both civilian and military use. The primary technology drivers are in the areas of ride quality, productivity and speed, Figure 22.

Continued improvement of the vibration and noise environment for passengers and crew is required for enhanced ride quality, the ultimate goal being a jet-smooth ride with low levels of internal and external noise. Key to this area is the understanding and control of the interaction of unsteady aerodynamics and structural dynamics, Figure 23. In FY 1985, measurement and analytical prediction of the complex rotor aerodynamics will be carried out. Concurrently, research on unsteady aerodynamics unique to rotors will be expanded to adapt proven fixed wing theories to rotorcraft. Comprehensive wind tunnel tests will be used to validate both the aerodynamic and structural dynamic theories.

A NASA/American Helicopter Society program, in conjunction with the FAA, has begun to address noise reduction, Figure 24. Bell Helicopter, Boeing Vertol, Hughes Helicopter and Sikorsky have joined in a team activity pooling with the expertise in our government laboratories to share results of noise theory fundamentals and noise reduction research. In FY 1985, parametric models will be tested and a comprehensive flight data base of rotor airloads will be acquired to serve as a basis for the development of acoustic theories. The ultimate goal is to predict the noise to within three decibels in new helicopter designs. We expect to achieve this goal by 1987.

The benefits to be achieved by increased speed in future missions are driving the examination of new concepts, such as X-Wing, Figure 25. A joint NASA/DARPA program has as its goal proof-of-concept through flight demonstration of an X-Wing rotor, using the NASA Rotor Systems Research Aircraft (RSRA) to validate aerodynamic and dynamic predictions in start/stop conversions at 200 knots. This technically challenging program involves NASA's aeronautical facilities and expertise at Ames Research Center, in conjunction with Sikorsky Aircraft, for rotor design and fabrication and RSRA modifications. Hover and low-speed forward flight transition characteristics will be defined in low-speed wind tunnel investigations. High-speed fixed-wing (stopped rotor) characteristics will be evaluated in transonic wind tunnel tests. Pneumatic control, higher-harmonic control and hub-moment feedback systems technology development will be supported during this next year.

The NASA Rotorcraft Research program will also continue to study technology for increased productivity. The emphasis will be on improved all-weather operations and decreased pilot workload levels -- both key areas of research.

Technology Advances in High-Performance Aircraft

Program objectives of the High-Performance Aircraft Technology program are to evolve and explore advanced concepts and generate validated analytical and design methodologies for future high-speed aircraft and missiles. Key program drivers are the development of technologies for advanced supersonic-cruise fighter aircraft, supersonic short take-off and vertical landing (STOVL) aircraft and hypersonic airbreathing aircraft and missiles, Figure 26.

Supersonic STOVL research, Figure 27, is directed toward the design and operation of efficient supersonic STOVL aircraft, resulting in operational capabilities of less than 400-foot take-off distance and of vertical landing. Design studies conducted over the past several years have identified several promising two-engine and single-engine STOVL concepts. The McDonnell Aircraft Company two-engine models have previously been studied both analytically and in wind tunnel testing. FY 1985 plans call for aerodynamic and wind tunnel studies of the General Dynamics single-engine concept. Basic studies of ejectors for lift augmentation will be conducted, including airframe effects on performance for both lift and reaction control response.

Research efforts are also directed at studies in flight control technology, simulation techniques and display concepts so as to improve the handling qualities of aircraft. The Ames Vertical Motion Simulator will be used in FY 1985 for a piloted evaluation of aircraft/propulsion controls methodology.

As an adjunct to our research program, NASA and the DOD are currently exploring the possibilities of a joint program with the United Kingdom in supersonic STOVL aircraft. The objective of the technology effort would be to reduce the time and resources required to build the necessary technical base for future STOVL development by pooling existing knowledge and working cooperatively to solve remaining technology uncertainties. A combined U.S./U.K. working group will meet at Ames Research Center in February 1984 to agree on the objectives, strategy and time scale of the plan.

The broad program objective in hypersonic aircraft/missile technology, Figure 28, is to develop the basis for Mach 3-8 operation. In FY 1985, initial hydrocarbon-fueled airbreathing aircraft and missile concepts are to be evaluated in wind tunnel tests at Langley Research Center. In addition, emphasis will be placed on aircraft propulsion with the development of dual-mode (Turbo/Ramjet) propulsion systems to provide operation across the full speed range. Hypersonic missile propulsion will emphasize hydrocarbon-fueled

scramjet technology with a near-term goal to demonstrate the applicability of existing hydrogen technology to hydrocarbon-fueled scramjets. In order to carry out the program efficiently, the 8-Foot High Temperature Structures Tunnel at Langley Research Center will be upgraded to expand its Mach number capability to allow relatively large supersonic combustion ramjet (scramjet) engine tests at Mach 4.5 and Mach 7.0.

Flight Research

Flight research is essential when technology development on potentially important and promising new concepts cannot be completed using analysis, simulation, and ground tests alone. Factors such as geometric scale effects, handling qualities, flight environment, dynamic behavior, pilot/flying qualities interface, and the interactions among multiple discipline technologies and system components, make flight testing an absolute necessity in the investigation of some technology advances.

Current NASA experimental aircraft programs involve flight research on high-performance fighters, rotorcraft, and general aviation aircraft, some of which are shown in Figure 29. A number of these programs are conducted in cooperation with DOD and industry.

NASA exploratory research is also generating several technology advances which may provide possible future experimental aircraft. Technology advances, shown in Figure 30, include:

- the oblique wing, which if pursued would require flight research on flying qualities and aeroelastic behavior at transonic speeds -- probably utilizing a modified existing aircraft as a test vehicle;

- the vortex flap, augmentor/ejector, and two-dimensional nozzles -- three technology options for future STOVL or STOL high-performance aircraft which if pursued would require flight testing to investigate feasibility and integration; and

- scramjet propulsion for hypersonic flight, involving integrated advances in propulsion, structure, and aerodynamics. Currently under investigation at small scale, scramjet propulsion if pursued would eventually require flight research on a new hypersonic-cruise research vehicle to complete the technology development and to permit the exploration of flight regimes well beyond present boundaries.

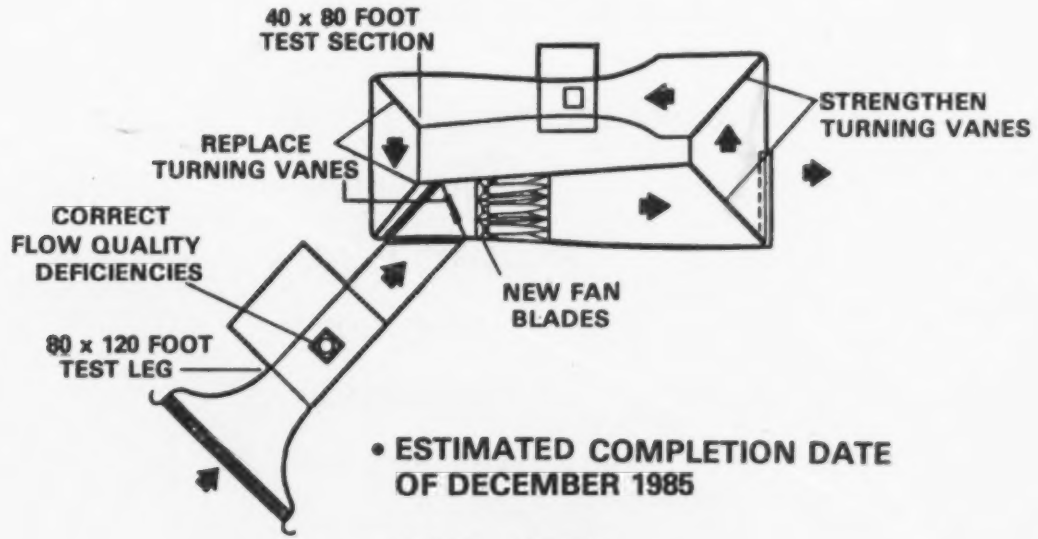
I have highlighted the major thrusts of the programs proposed in our FY 1985 request. These are described in considerable detail in the narrative budget material. As Mr. Beggs indicated in his written statement to your Subcommittee on December 5, 1983, successful realization of the important technology opportunities for continued aeronautical advancement through the remainder of this century and into the next will require dedicated effort and commitment. NASA's aeronautical research and technology activity must remain a crucial element of the required effort to identify and develop the high-payoff technologies. I believe the FY 1985 budget request is a healthy step and an appropriate step in this direction. I am confident that, with the continued support of this Subcommittee, we will attain our ambitious technology goals and lay the basis for realizing many of the exciting capabilities we have described. Thank you, Mr. Chairman.

MAJOR PROGRAMMATIC THRUSTS

- AIRCRAFT STRUCTURES
- AERODYNAMICS
- PROPULSION
- FLIGHT CONTROLS
- ROTORCRAFT
- HIGH PERFORMANCE AIRCRAFT

REPAIRS TO THE 40 x 80 x 120 FOOT WIND TUNNEL

FACILITY PLAN VIEW



- ESTIMATED COMPLETION DATE OF DECEMBER 1985
- COST: $26.5M

NASA

OAST NASA HQ R84-778(1) REV. 2-2-84

Chart B

AERONAUTICAL RESEARCH AND TECHNOLOGY

R&D BUDGET ($,M)

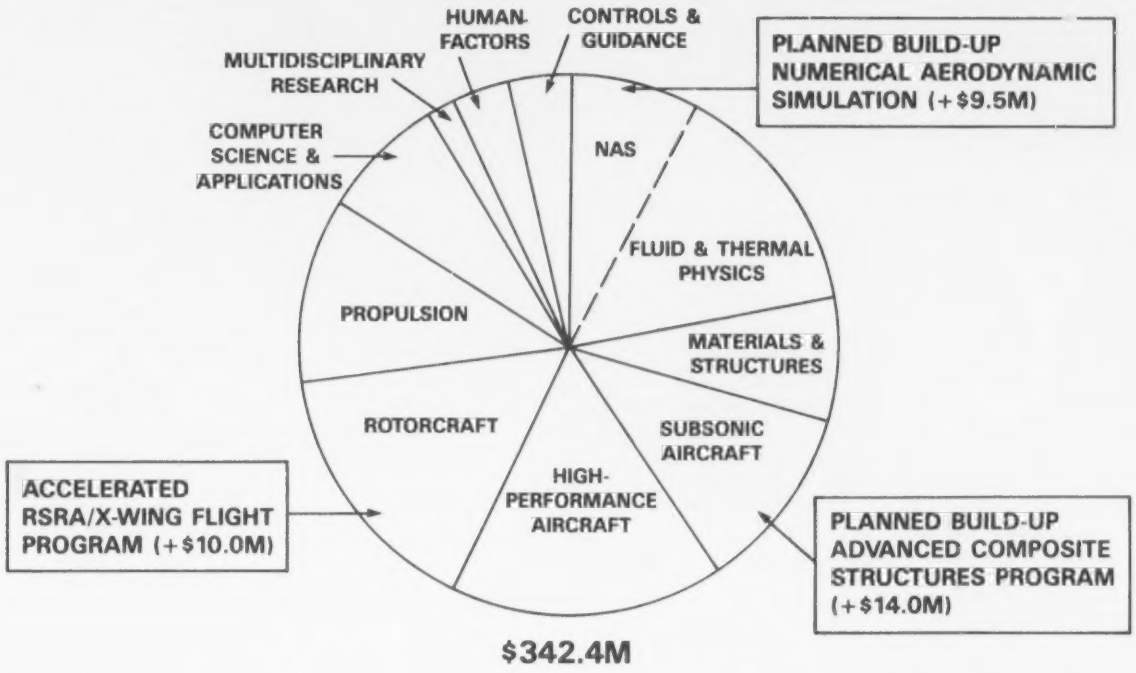
	FY 1983	FY 1984 BUDGET ESTIMATE	FY 1984 CURRENT ESTIMATE	FY 1985 BUDGET ESTIMATE
RESEARCH & TECHNOLOGY BASE	198.5	227.8	215.8	233.3
SYSTEMS TECHNOLOGY PROGRAMS	81.5	72.5	86.5	109.1
TOTAL	280.0	300.3	302.3	342.4

NASA

Figure 1

OAST NASA HQ R84-793 (1) 1-19-84

FY 1985 AERONAUTICS PROGRAM
DISTRIBUTION BY PROGRAM AREA

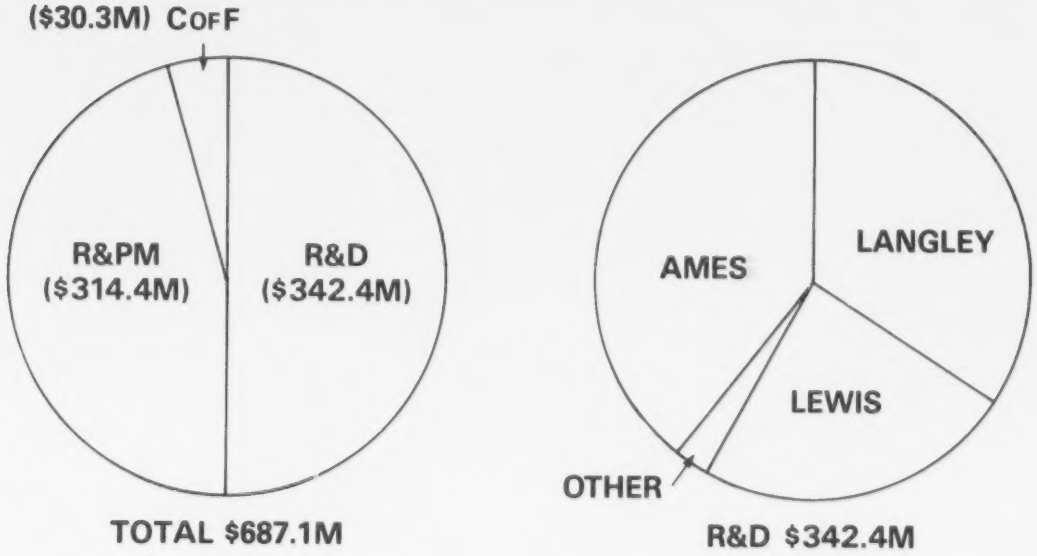


NASA

Figure 2

OAST NASA HQ R84-688(1) 1-11-84

NASA AERONAUTICS PROGRAM
FY 1985



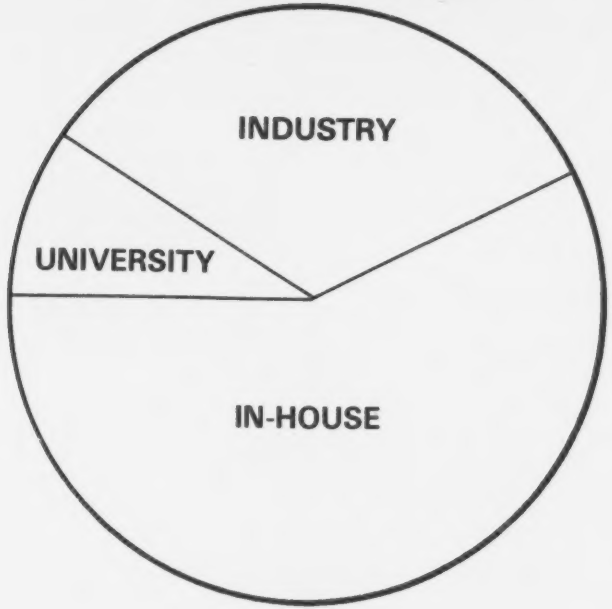
NASA

Figure 3

OAST NASA HQ R84-689(1)
1-11-84

AERONAUTICAL RESEARCH AND TECHNOLOGY

FY 1985 R&D BUDGET



$342.4M

NASA

Figure 4

OAST NASA HQ R84-791 (1) 1-19-84

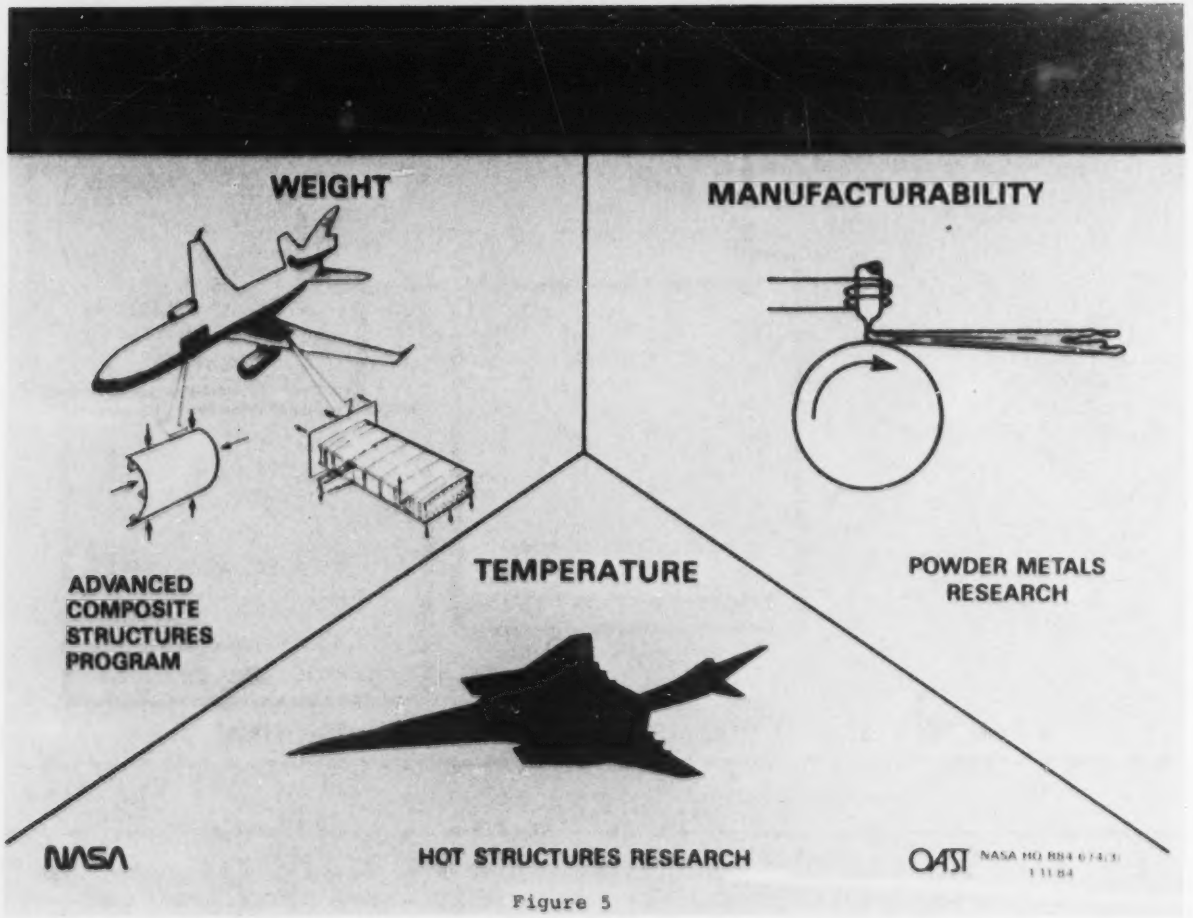

WEIGHT
MANUFACTURABILITY
ADVANCED
COMPOSITE
STRUCTURES
PROGRAM
TEMPERATURE
POWDER METALS
RESEARCH
NASA
HOT STRUCTURES RESEARCH
OAST

Figure 5

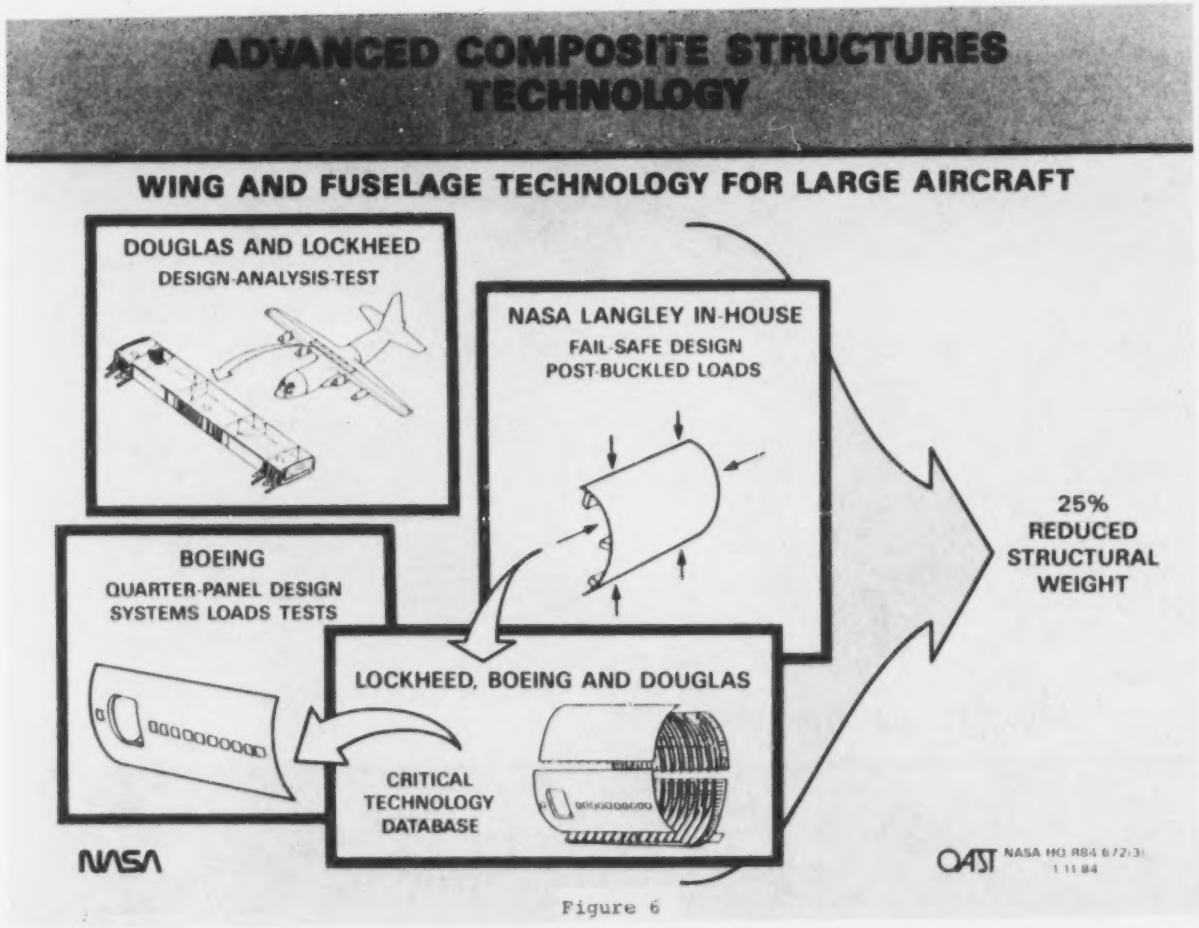

ADVANCED COMPOSITE STRUCTURES TECHNOLOGY
WING AND FUSELAGE TECHNOLOGY FOR LARGE AIRCRAFT
DOUGLAS AND LOCKHEED
DESIGN-ANALYSIS-TEST
NASA LANGLEY IN-HOUSE
FAIL-SAFE DESIGN
POST-BUCKLED LOADS
BOEING
QUARTER-PANEL DESIGN
SYSTEMS LOADS TESTS
LOCKHEED, BOEING AND DOUGLAS
CRITICAL
TECHNOLOGY
DATABASE
25%
REDUCED
STRUCTURAL
WEIGHT
NASA
OAST

Figure 6

RAPIDLY SOLIDIFIED ALUMINUM ALLOYS

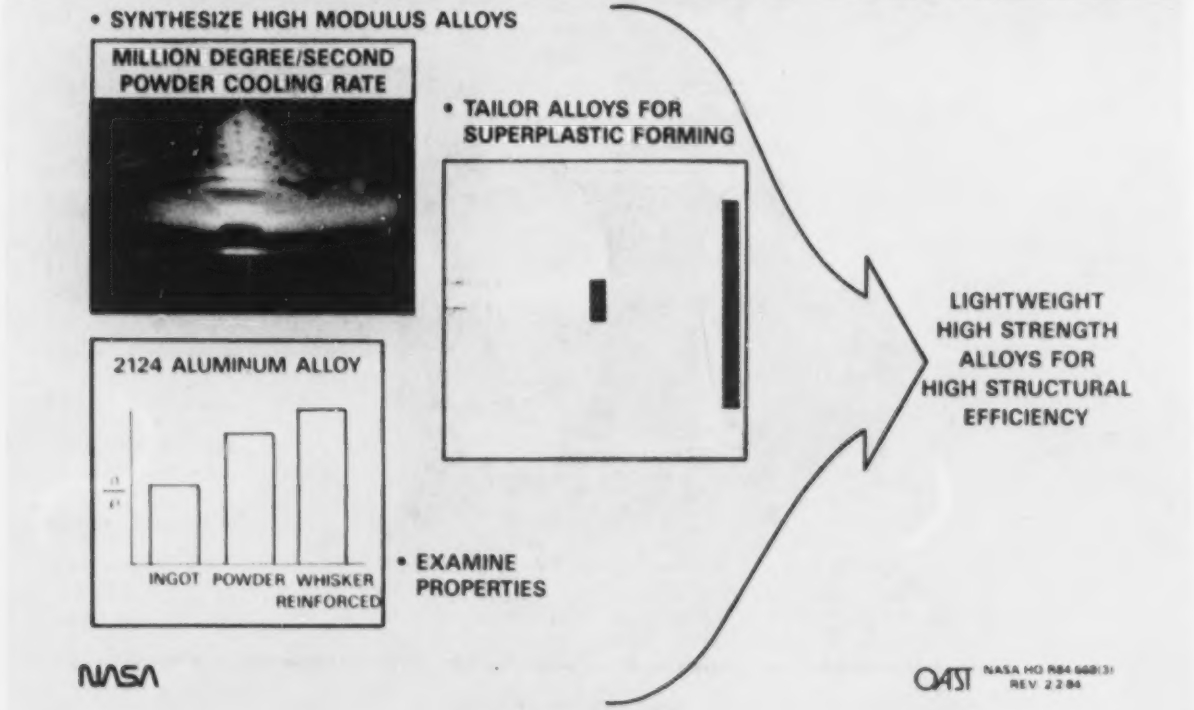


Figure 7

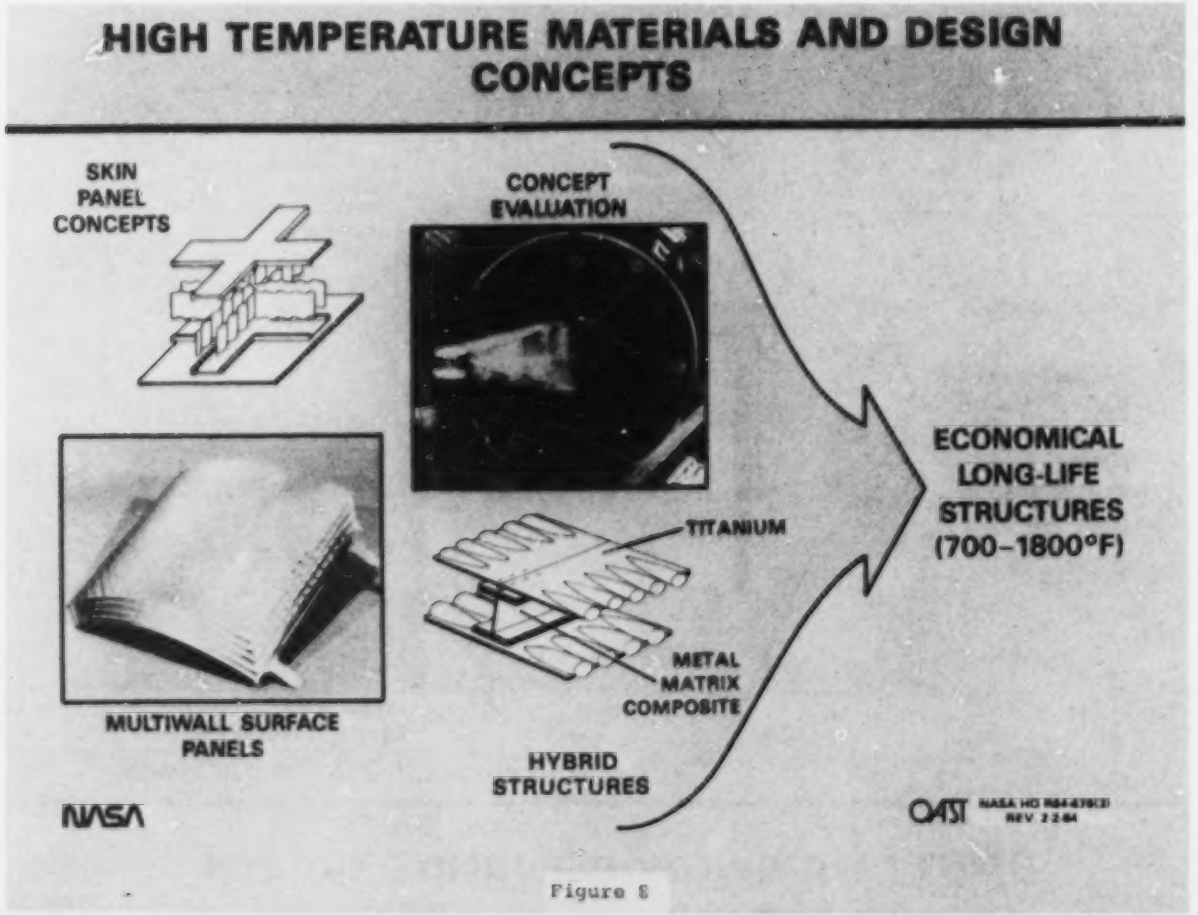

HIGH TEMPERATURE MATERIALS AND DESIGN CONCEPTS
SKIN PANEL CONCEPTS
CONCEPT EVALUATION
MULTIWALL SURFACE PANELS
TITANIUM
METAL MATRIX COMPOSITE
HYBRID STRUCTURES
ECONOMICAL LONG-LIFE STRUCTURES (700–1800°F)
NASA
OAST

Figure 8

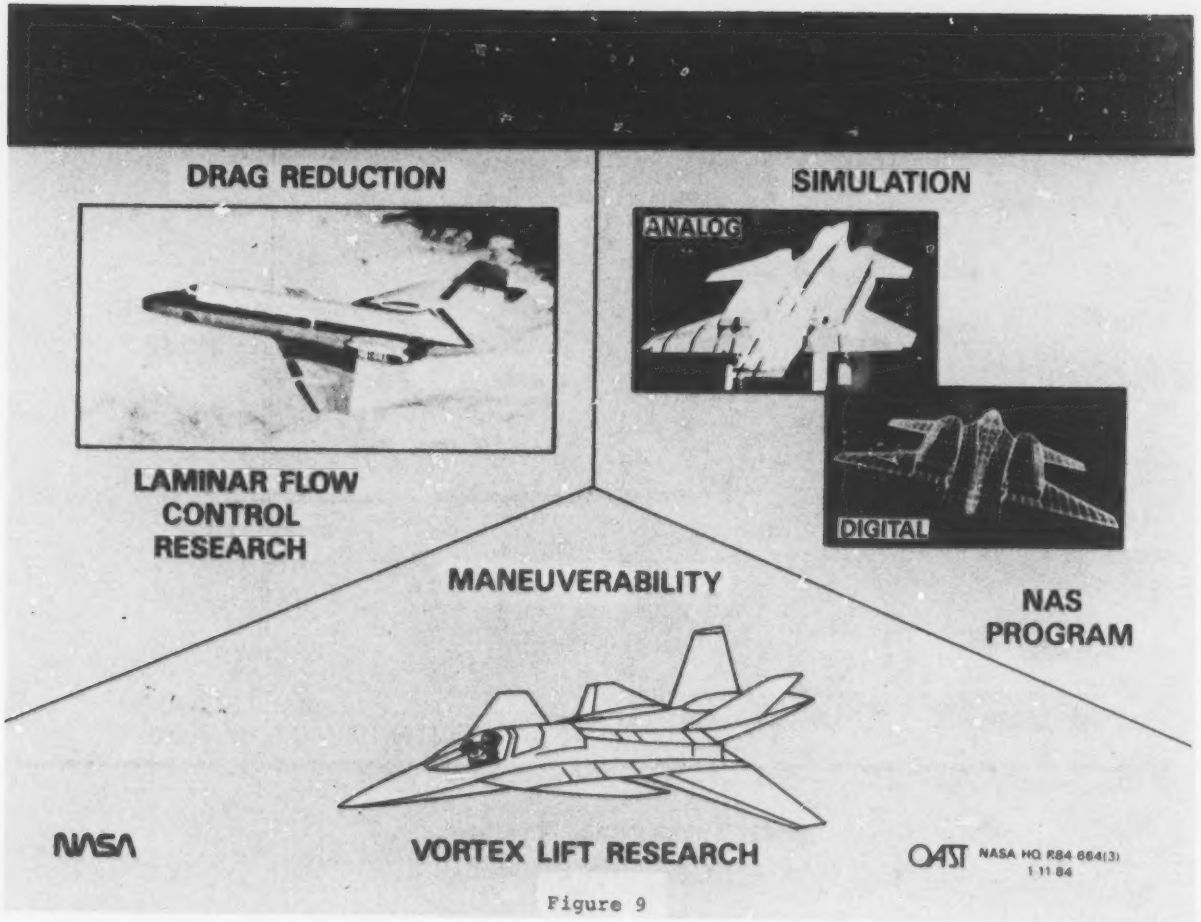
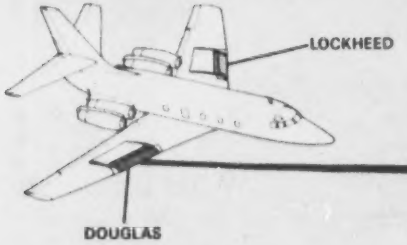
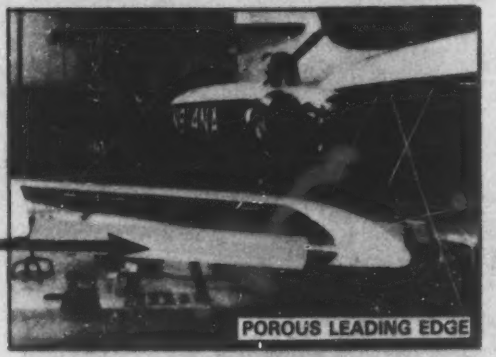

DRAG REDUCTION
LAMINAR FLOW CONTROL RESEARCH
SIMULATION
ANALOG
DIGITAL
NAS PROGRAM
MANEUVERABILITY
VORTEX LIFT RESEARCH
NASA
OAST
NASA HQ R84 664(3)
1 11 84

Figure 9

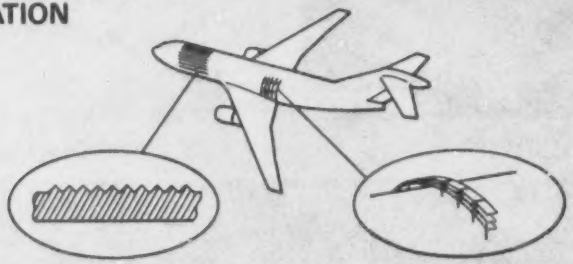
DRAG REDUCTION

LAMINAR FLOW CONTROL FLIGHT TESTS





TURBULENT FLOW CONTROL FLIGHT EVALUATION

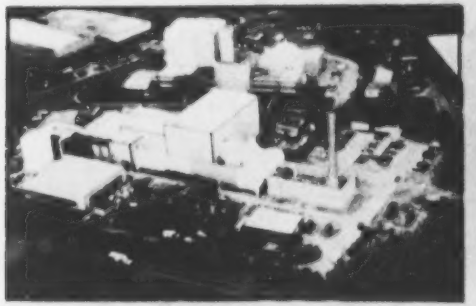


NASA

OAST NASA HQ RSH-665(3) REV. 2-2-84

Figure 10

NATIONAL TRANSONIC FACILITY



- DEDICATED DECEMBER 1983
- CALIBRATION AND TESTING – 1984
- FULLY OPERATIONAL – 1985
  - X-29
  - NASA SHUTTLE
  - COMMERCIAL TRANSPORTS
- WIND TUNNEL FLIGHT CORRELATION

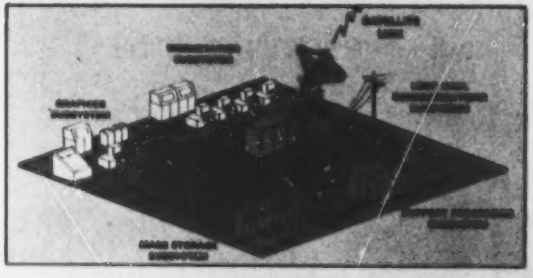
NASA

OAST NASA HQ R584 715(3) REV. 2 2 84

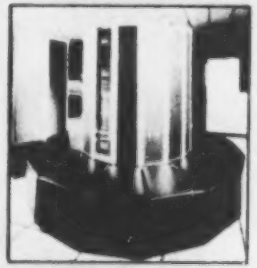
Figure 11

NUMERICAL AERODYNAMIC SIMULATION

NATIONAL COMPUTATIONAL CAPABILITY



HIGH-SPEED PROCESSOR #1



DELIVERY AND INITIATION OF DEVELOPMENTAL OPERATIONS

FY 1985

HIGH-SPEED DATA NETWORK

- INSTALLATION OF LONG-HAUL COMMUNICATION SUBSYSTEM
- AQUISITION AND ASSEMBLY OF SUBSYSTEMS

NETWORK TESTBED IN PLACE

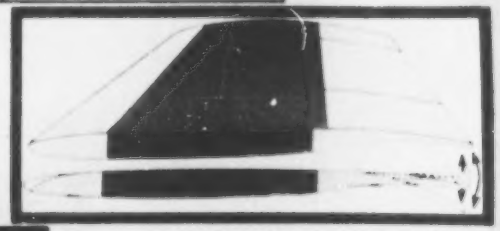
NASA

OAST NASA HQ 884 679(3) 1 11 84

Figure 12

INCREASED MANEUVERABILITY

VORTEX LIFT AUGMENTATION TESTS



VARIABLE WING CAMBER
FLIGHT RESEARCH

THRUST VECTORING
RESEARCH

- TIGHT TURN RADIUS
- AGILITY
- HIGH PITCH ANGLE

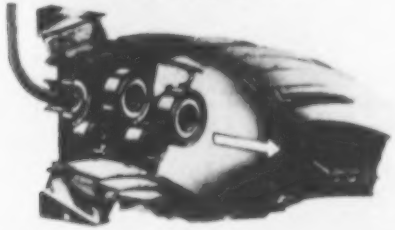
NASA

OAST NASA HQ 884-6.7.7(3)
1.11.84

Figure 13

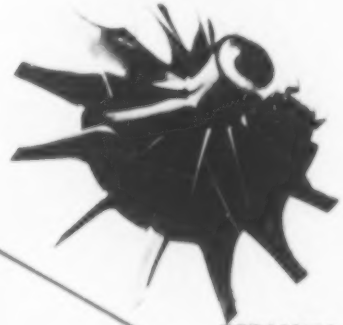
TECHNOLOGY FOR ADVANCES IN PROPULSION

DURABILITY



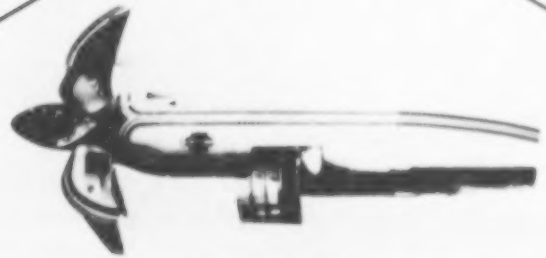
HOT SECTION
TECHNOLOGY
PROGRAM

THRUST/WEIGHT



CERAMICS
RESEARCH

FUEL EFFICIENCY



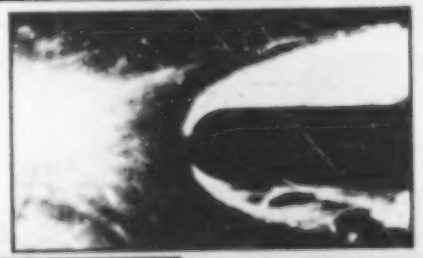
ADVANCED TURBOPROP PROGRAM

NASA

OAST

Figure 14

HOT SECTION TECHNOLOGY



INVESTIGATE MULTIPLE JET DILUTION MIXING

DEVELOP HIGH TEMPERATURE STRAIN SENSORS

NASA

PERFORM 3 D INELASTIC THERMAL STRUCTURAL ANALYSIS OF BLADES

INVESTIGATE HOT CORROSION

LONGER LIFE COMPONENTS (2×)

OAST

Figure 15

ADVANCED TURBOPROP PROGRAM

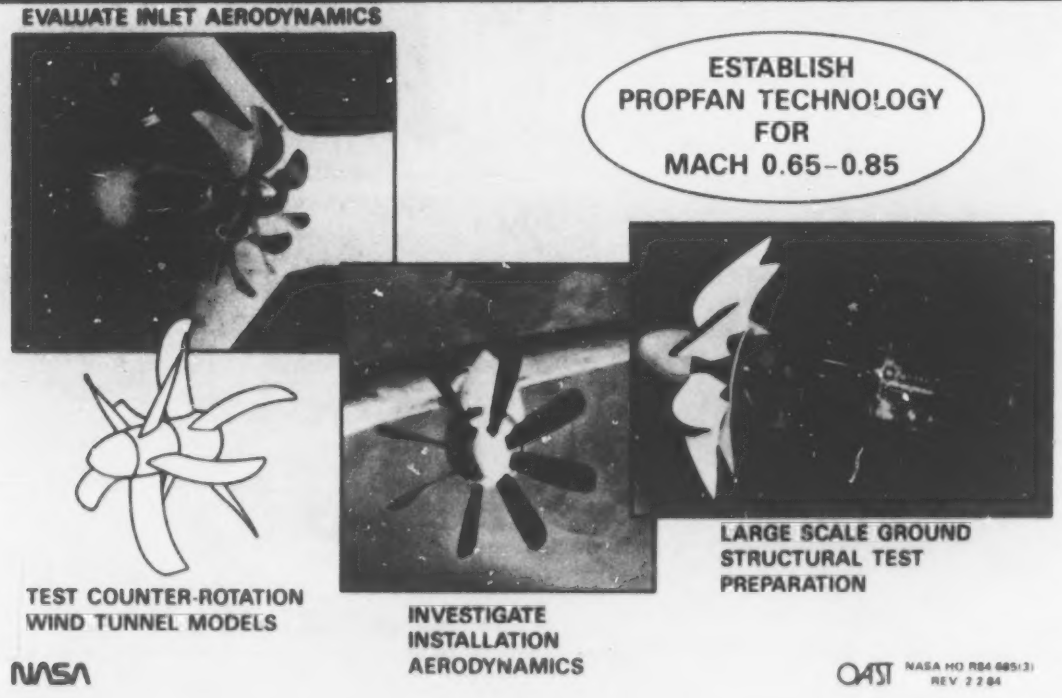
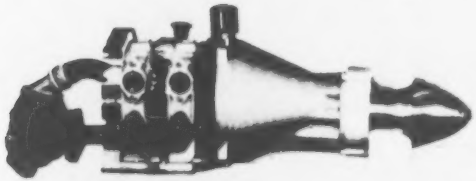

EVALUATE INLET AERODYNAMICS
ESTABLISH PROPFAN TECHNOLOGY FOR MACH 0.65–0.85
TEST COUNTER-ROTATION WIND TUNNEL MODELS
INVESTIGATE INSTALLATION AERODYNAMICS
LARGE SCALE GROUND STRUCTURAL TEST PREPARATION
NASA
OAST
NASA HQ R84 665(3) REV 2 2 84

Figure 16

GENERAL AVIATION PROPULSION TECHNOLOGY

TURBOCHARGED ROTARY ENGINES



REDUCED FUEL 25%
REDUCED WEIGHT 35%
HIGH ALTITUDE CAPABILITY
FUEL FLEXIBILITY

- EVALUATE CERAMIC-COATED TITANIUM ROTOR
- TEST HIGH-PRESSURE FUEL INJECTION
- STUDY ROTOR INJECTED FLOW

ADIABATIC DIESEL ENGINES

- TEST CERAMICS FOR
  - PISTON
  - CYLINDER LINER
  - HEAD LINER

NASA

OAST

Figure 17

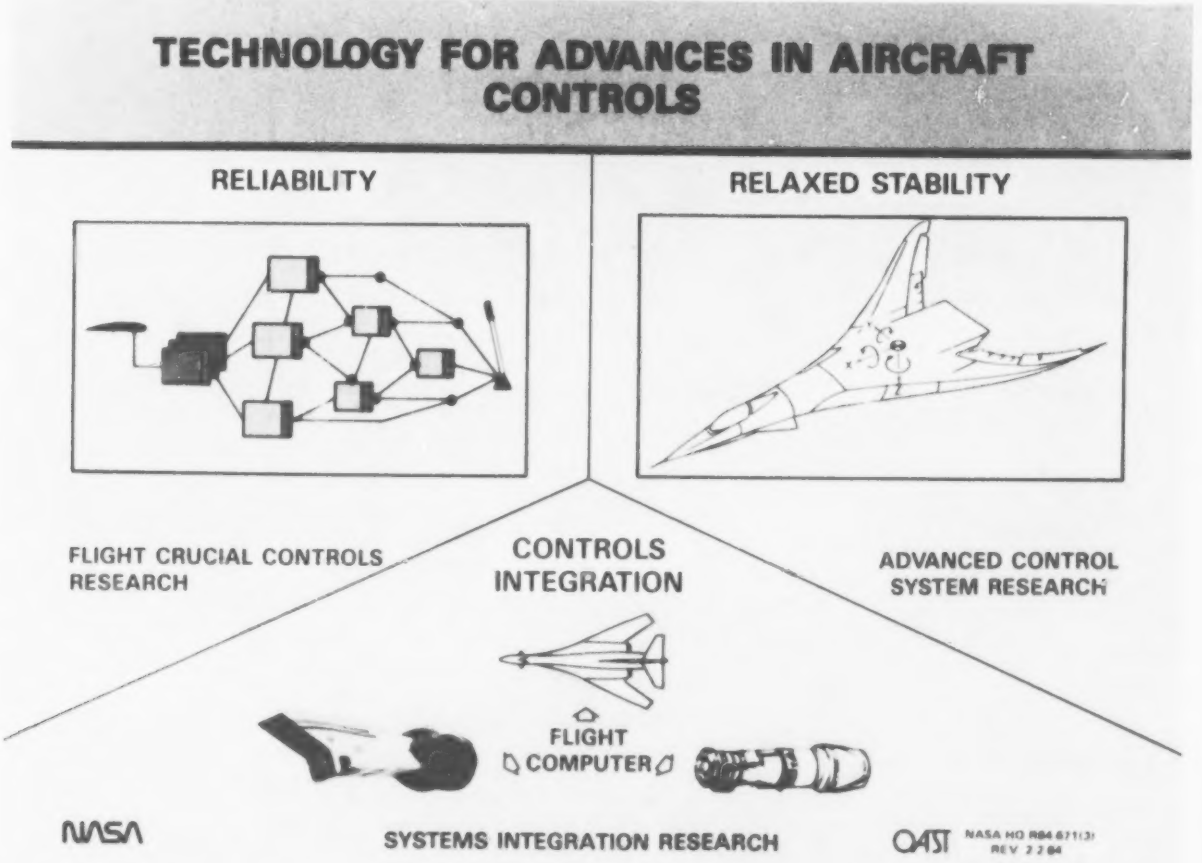
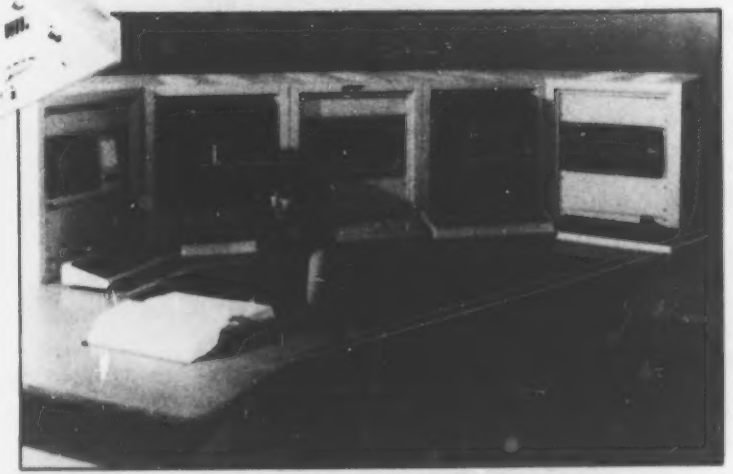

TECHNOLOGY FOR ADVANCES IN AIRCRAFT CONTROLS
RELIABILITY
RELAXED STABILITY
FLIGHT CRUCIAL CONTROLS RESEARCH
CONTROLS INTEGRATION
ADVANCED CONTROL SYSTEM RESEARCH
FLIGHT COMPUTER
NASA
SYSTEMS INTEGRATION RESEARCH
OAST
NASA HQ R84 671(3) REV 2 2 84

Figure 12

RESEARCH IN FLIGHT CRUCIAL CONTROLS

AIRLAB

OPERATIONAL IN 1983



- ASSESS FAULT TOLERANT CONCEPTS
- ANALYZE RECOVERY RATES
- MODEL HARDWARE ERRORS

ELECTRONIC CONTROL SYSTEMS AS RELIABLE AS PRIMARY STRUCTURE

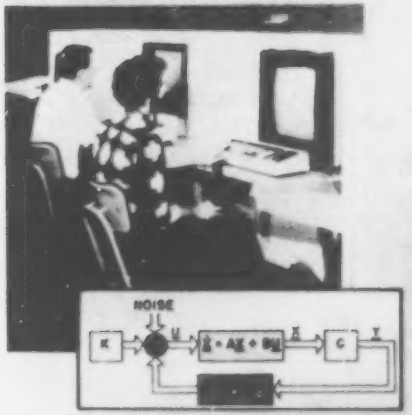
NASA

OAST NASA HQ R84 666(3) REV 2 2 84

Figure 19

ADVANCED CONTROL SYSTEM RESEARCH

- DESIGN AND ANALYZE CANDIDATE CONTROL LAWS



- VALIDATE CONTROL SYSTEM BY SIMULATION

- EVALUATE HANDLING QUALITIES THROUGH FLIGHT TEST

EXPAND FLIGHT ENVELOPE FOR UNSTABLE FLEXIBLE AIRCRAFT

NASA

OAST

Figure 20

AIRFRAME/PROPULSION CONTROLS INTEGRATION RESEARCH

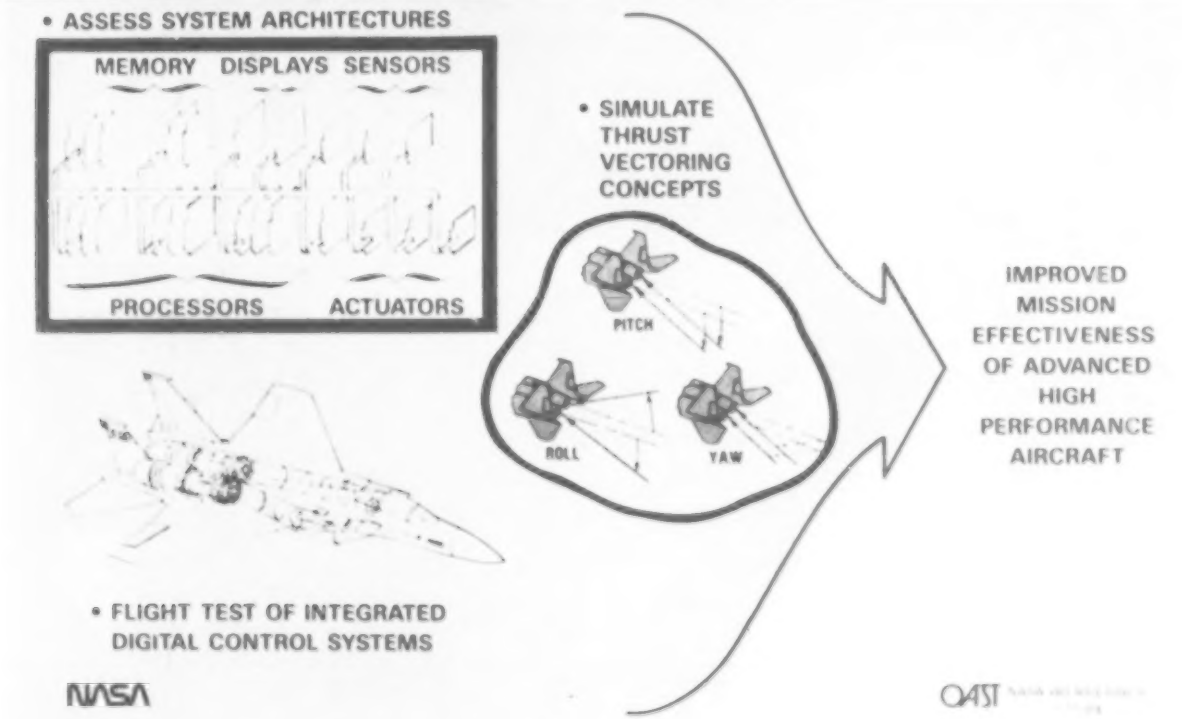
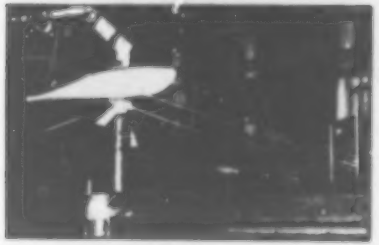


Figure 21

ADVANCES IN ROTORCRAFT

RIDE QUALITY



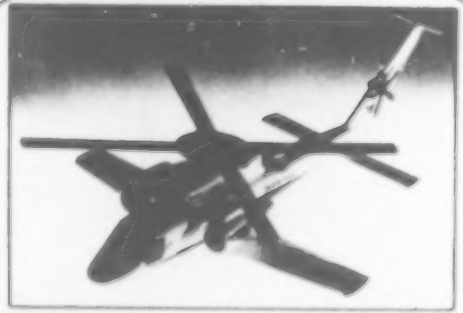
NOISE AND VIBRATION RESEARCH

PRODUCTIVITY

ALL-WEATHER OPERATIONS RESEARCH

HUMAN FACTORS RESEARCH

SPEED

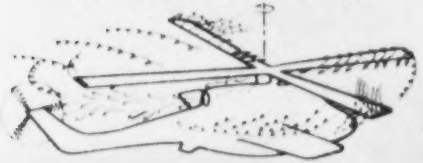


RSRA/X-WING ROTOR FLIGHT PROGRAM

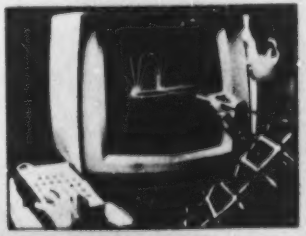
NASA

ROTORCRAFT AEROMECHANICS

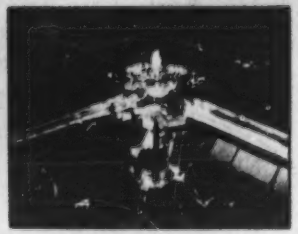
MAP DETAILED AERODYNAMICS



ADAPT FIXED WING THEORIES TO ROTORCRAFT



CONDUCT COMPREHENSIVE WIND TUNNEL TESTS



CHARACTERIZE STRUCTURAL DYNAMICS

50% REDUCTION IN LOADS AND VIBRATION

NASA

OAST

Figure 23

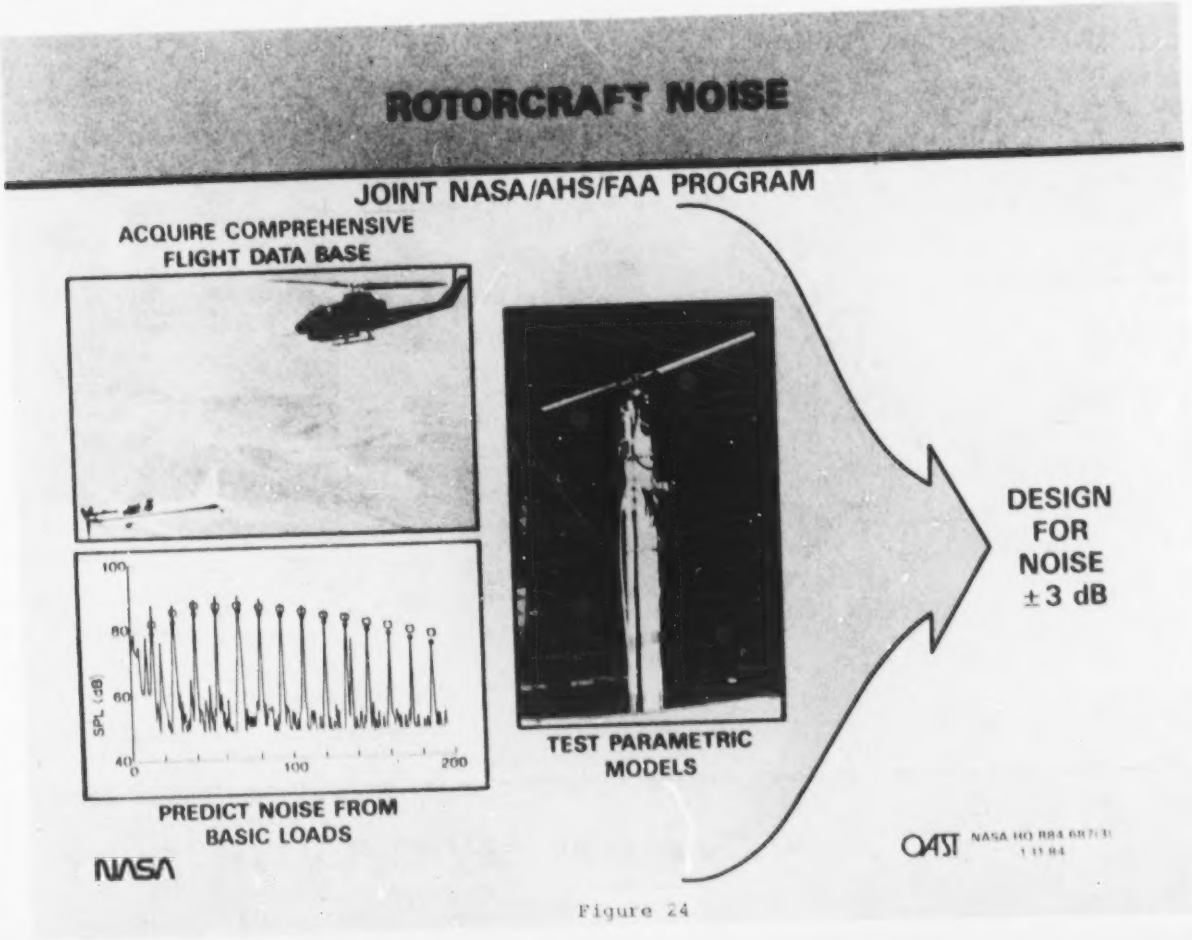
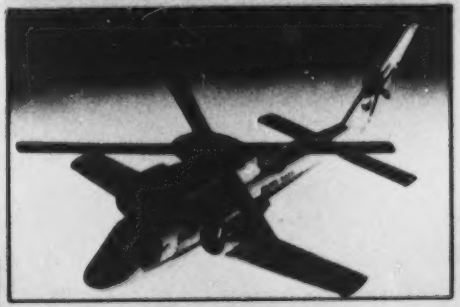

ROTORCRAFT NOISE
JOINT NASA/AHS/FAA PROGRAM
ACQUIRE COMPREHENSIVE FLIGHT DATA BASE
SPL (dB)
100
80
60
40
0
100
200
PREDICT NOISE FROM BASIC LOADS
TEST PARAMETRIC MODELS
DESIGN FOR NOISE ±3 dB
NASA
OAST

Figure 24

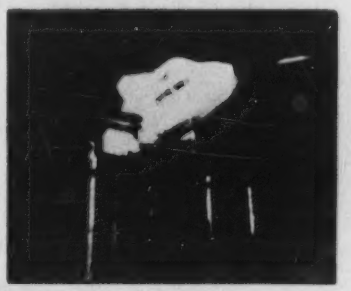
RSRA/X-WING FLIGHT PROGRAM

JOINT NASA/DARPA PROGRAM



UTILIZE UNIQUE RSRA CAPABILITY

- **VALIDATE AERODYNAMIC AND DYNAMIC PREDICTIONS**
- **INVESTIGATE STOP-START CONVERSION**



NASA

OAST NASA HQ 884 682(3) 1 11 84

Figure 25

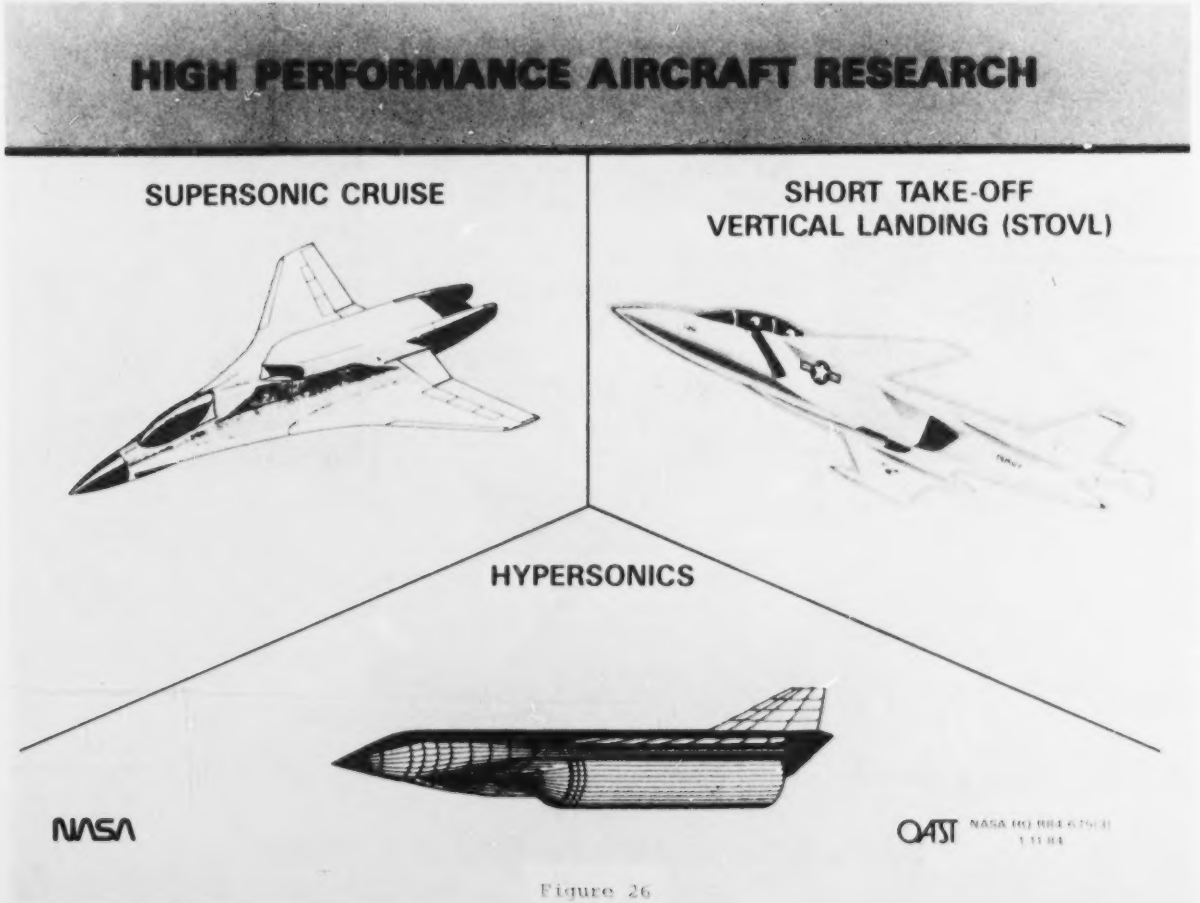

HIGH PERFORMANCE AIRCRAFT RESEARCH
SUPERSONIC CRUISE
SHORT TAKE-OFF
VERTICAL LANDING (STOVL)
HYPERSONICS
NASA
OAST

Figure 26

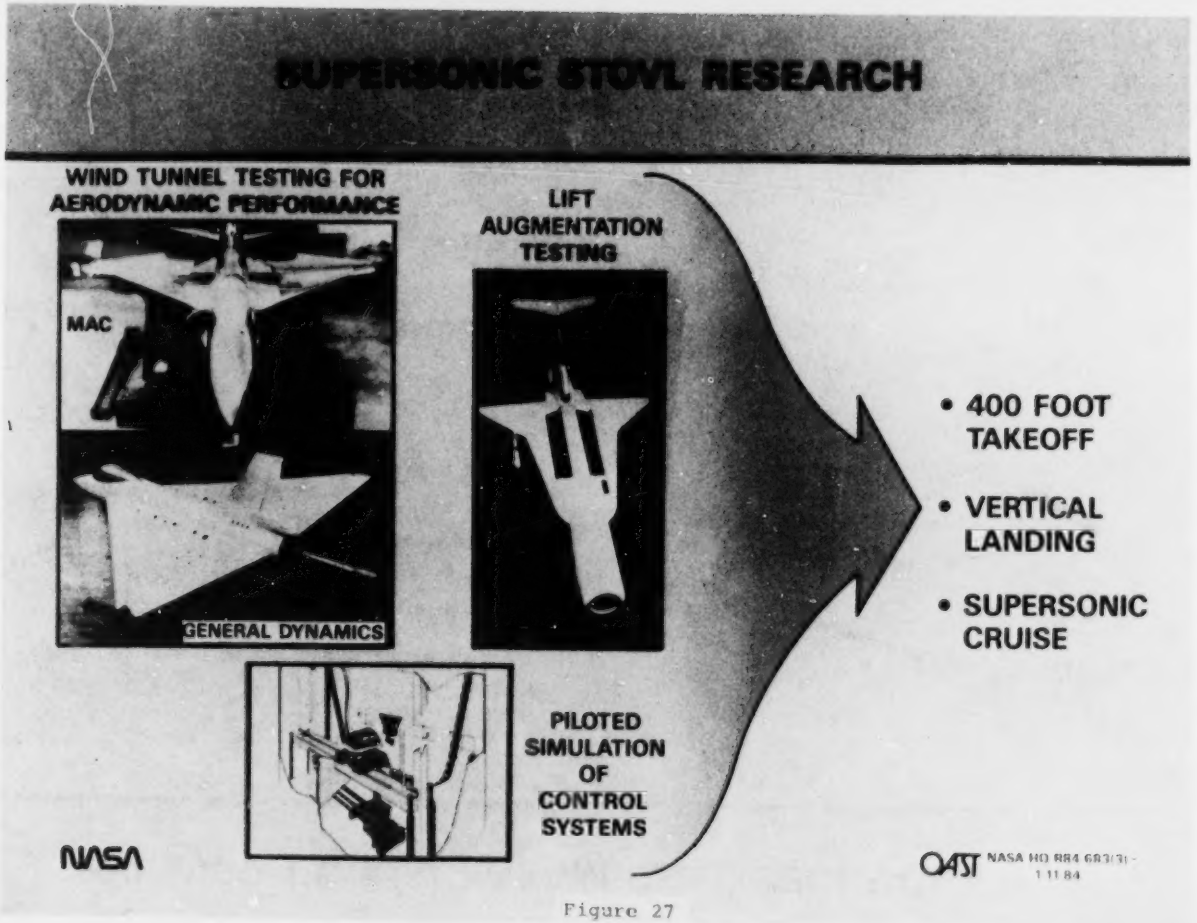

SUPERSONIC STOVL RESEARCH
WIND TUNNEL TESTING FOR AERODYNAMIC PERFORMANCE
MAC
GENERAL DYNAMICS
LIFT AUGMENTATION TESTING
PILOTED SIMULATION OF CONTROL SYSTEMS
• 400 FOOT TAKEOFF
• VERTICAL LANDING
• SUPERSONIC CRUISE
NASA
OAST
NASA HQ 884 683(3) - 1 11 84

Figure 27

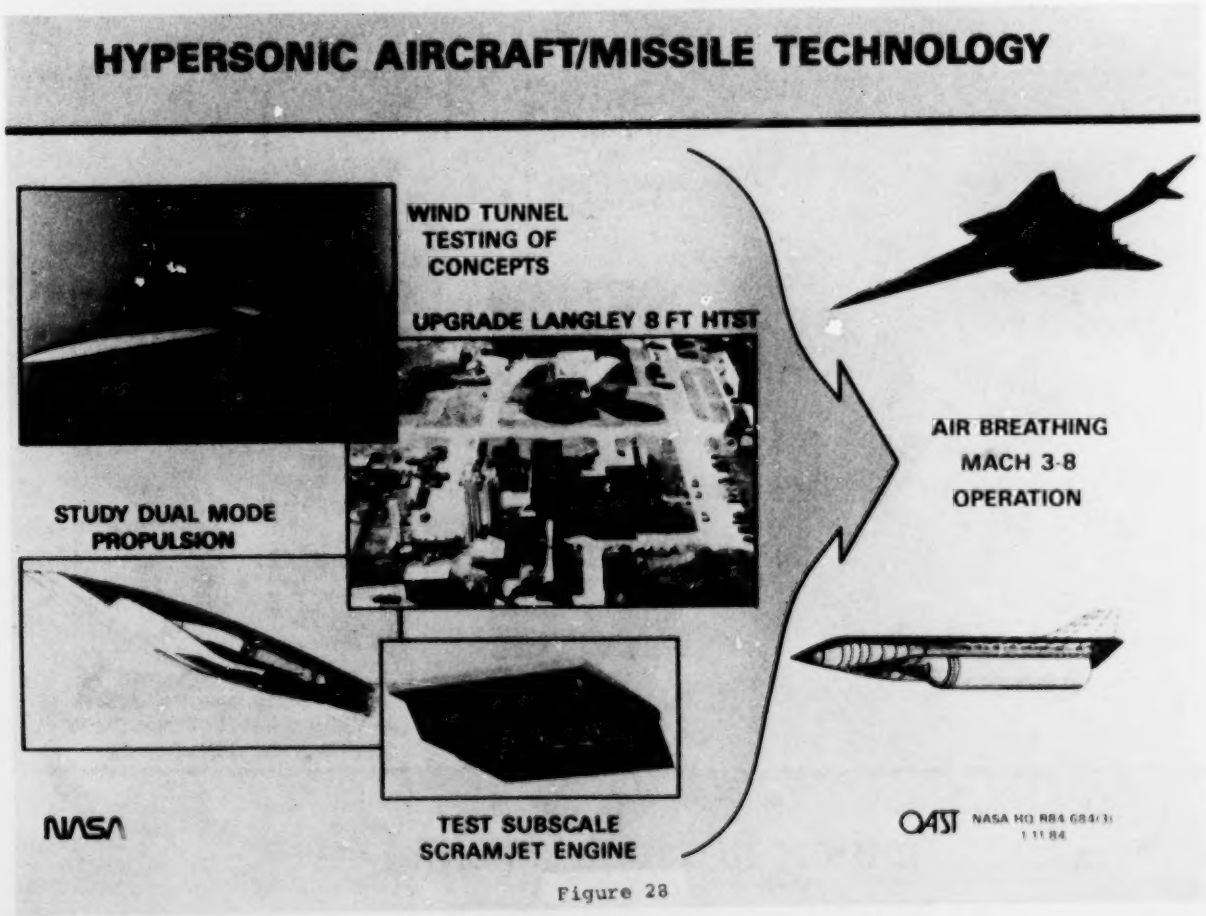

HYPERSONIC AIRCRAFT/MISSILE TECHNOLOGY
WIND TUNNEL TESTING OF CONCEPTS
UPGRADE LANGLEY 8 FT HTST
STUDY DUAL MODE PROPULSION
AIR BREATHING MACH 3-8 OPERATION
TEST SUBSCALE SCRAMJET ENGINE
NASA
OAST
NASA HQ 884 684(3)
1 11 84

Figure 28

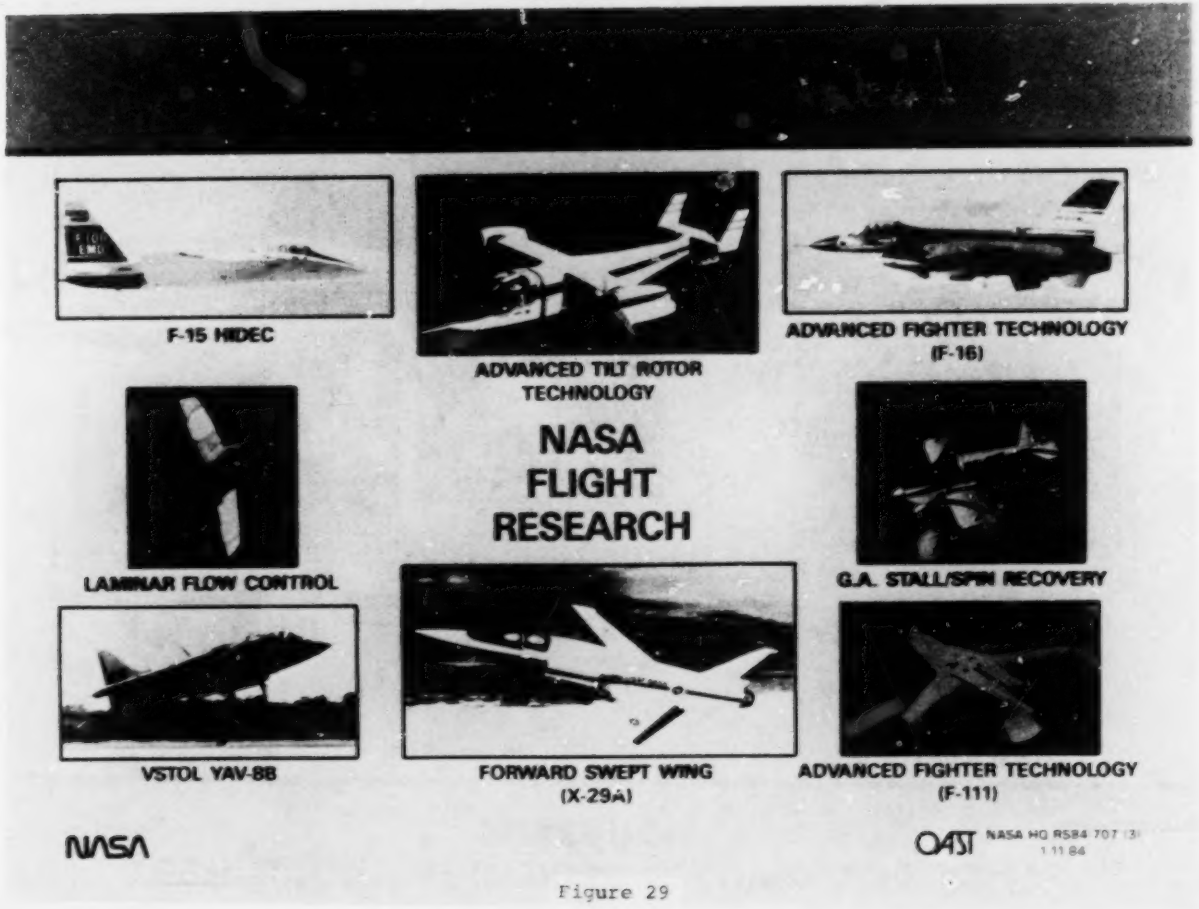

F-15 HIDEC
ADVANCED TILT ROTOR TECHNOLOGY
ADVANCED FIGHTER TECHNOLOGY (F-16)
NASA FLIGHT RESEARCH
LAMINAR FLOW CONTROL
G.A. STALL/SPIN RECOVERY
VSTOL YAV-8B
FORWARD SWEPT WING (X-29A)
ADVANCED FIGHTER TECHNOLOGY (F-111)
NASA
OAST
NASA HQ RS84 707 (3)
1.11.84

Figure 29

APPENDIX

Air Transport Association ata OF AMERICA

1709 New York Avenue, NW
Washington, DC 20006
Phone (202) 626-4000

March 1, 1984

The Honorable Dan R. Glickman
Chairman, Subcommittee on Transportation,
Aviation and Materials
Committee on Science and Technology
U.S. House of Representatives
Washington, D.C. 20515

Dear Mr. Chairman:

For several years the Air Transport Association has expressed its strong support for an agressive schedule for prop-fan development, including the Phase III testing of specially modified aircraft. We believe that the prop-fan program has the potential for substantial energy efficiency improvements in the air transport field and continue to support its accelerated development for commercial application.

Unfortunately, it is our understanding that the FY 1985 NASA budget for the prop-fan program reflects a reduction from $40 million to $14 million. This will eliminate the Phase III flight testing necessary for full-scale flight verification.

This program and others like it are vitally important to the airlines because they can significantly improve the productivity of air transportation in the future. Because research efforts are already producing encouraging results, we believe that the budget should be restored to fully fund the prop-fan program through to its conclusion. We urge the Subcommittee to restore authorized funding for FY 1985 NASA research on the prop-fan to $40 million, and to authorize adequate funding for the Phase III flight test.

Sincerely,

William J. Burhop

William J. Burhop
Senior Vice President
Government Affairs

DELTA AIR LINES, INC.

February 29, 1984

Honorable Dan Glickman
Chairman
Subcommittee on Transportation,
Aviation & Materials
Committee on Science & Technology
U.S. House of Representatives
Washington, D. C. 20515

Dear Mr. Chairman:

It has been brought to my attention that once again your Subcommittee is considering funding for the NASA Advanced Turboprop Program (ATP). It is my understanding that the Administration's FY 85 Budget provides for only $14 million for the program, but another $26+ million is essential for appropriate research and development progress to be made.

I would like to re-emphasize the importance of this program to develop fuel-efficient prop fan propulsion systems for air transports. As you know, Delta has one of the most fuel-efficient operations in the industry. However, to maintain this position in the future and for the benefit of the entire industry, new technology such as the prop fan must be developed.

As I have stated to you before, the manufacturing and air transportation industries of this country surely need to press for every potential advantage which may become available in the field of design improvements.

Sincerely,

D. P. Hettermann
Senior Vice President
Technical Operations

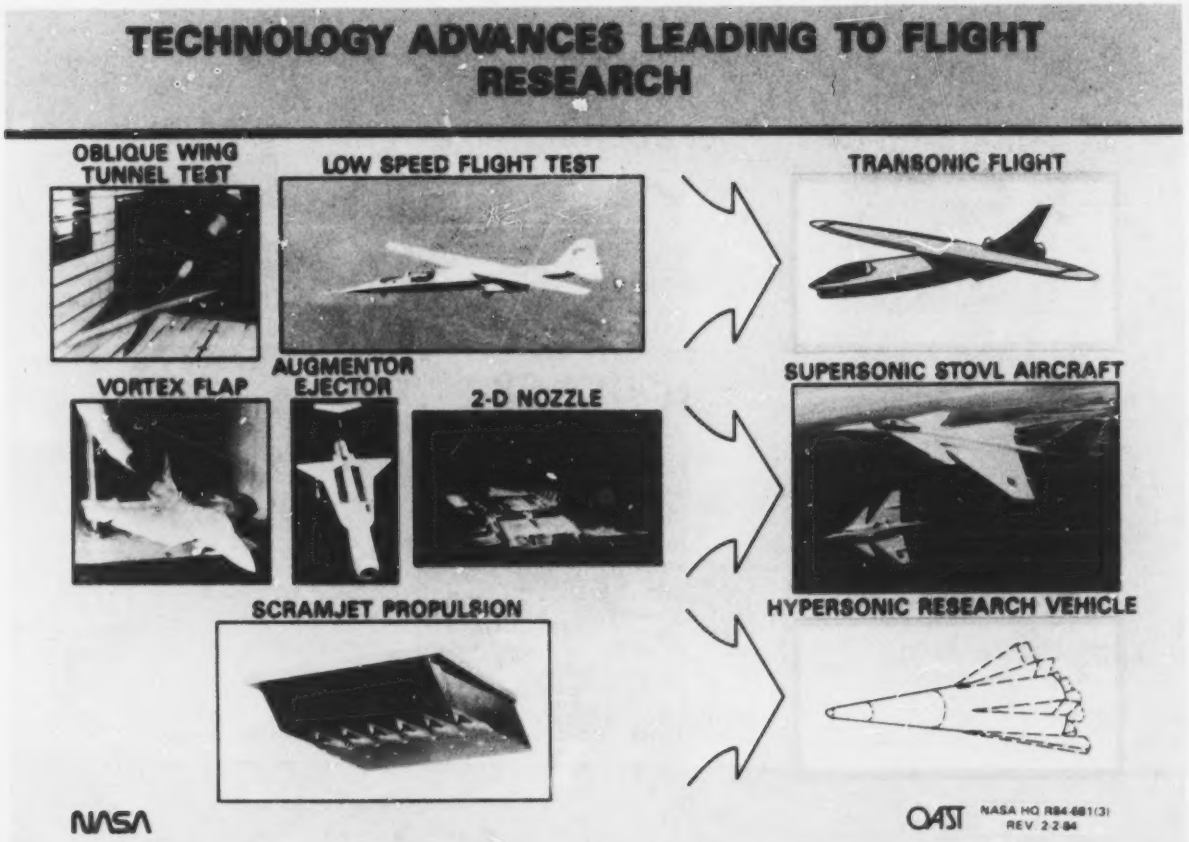

TECHNOLOGY ADVANCES LEADING TO FLIGHT RESEARCH
OBLIQUE WING TUNNEL TEST
LOW SPEED FLIGHT TEST
TRANSONIC FLIGHT
VORTEX FLAP
AUGMENTOR EJECTOR
2-D NOZZLE
SUPERSONIC STOVL AIRCRAFT
SCRAMJET PROPULSION
HYPERSONIC RESEARCH VEHICLE
NASA
OAST
NASA HQ R84-681(3)
REV 2-2-84

Figure 30